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REAPS

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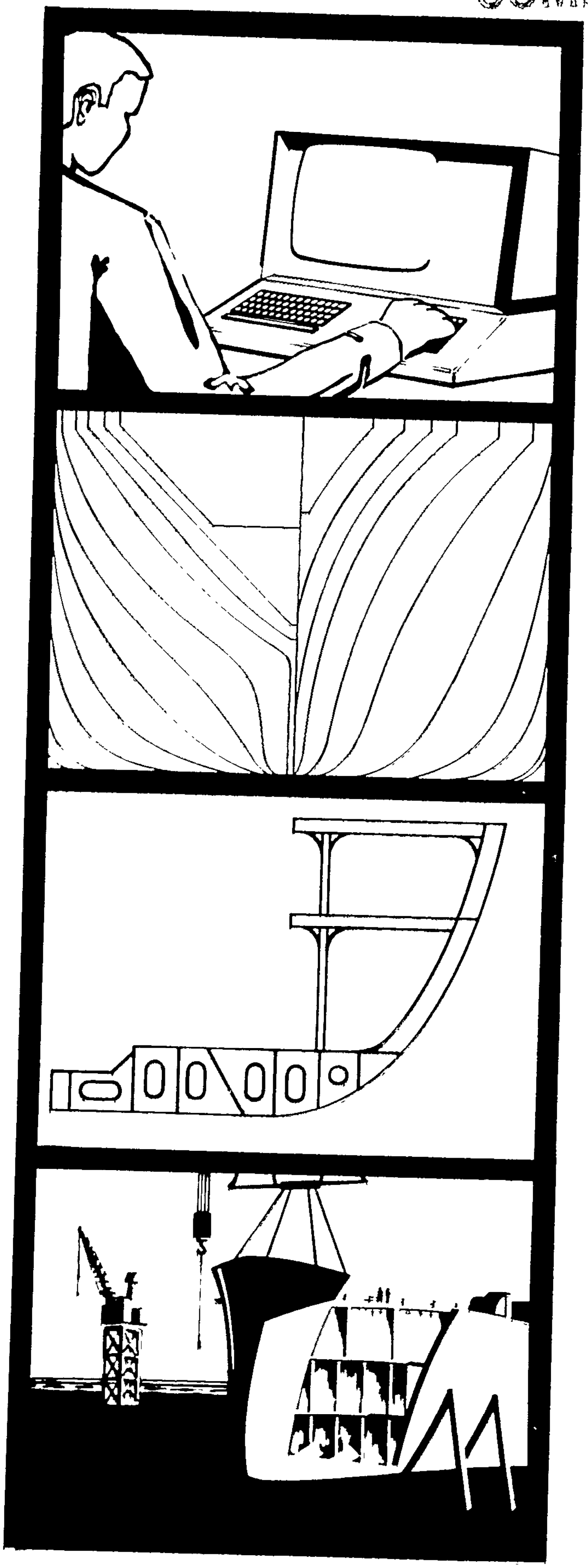

R ESEARCH
AND
E NGINEERING
FOR
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AND
P RODUCTIVITY
IN
S HIPBUILDING

Proceedings of the
REAPS Technical Symposium
September 11-13, 1979
San Diego, California

Report Documentation Page

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Proceedings of the

REAPS Technical Symposium

September II-13,1979

San Diego, California

Research and
Engineering for
Automation and
Productivity in
shipbuilding

I IT RESEARCH INSTITUTE
10 WEST 35 STREET
CHICAGO, ILLINOIS 60616

The Seventh Annual REAPS Technical Symposium will be held in Philadelphia, Pennsylvania in October 1980.

Proceedings of prior REAPS Technical Symposia are available from the REAPS Librarian, IIT Research Institute,' 10 West 35th Street, Chicago, Illinois 60616. All hard copy volumes are $25 each through 1977, $30 for 1978, and all microfiche $5 each. To order specify year, reference number and medium desired:

	Reference Number	
Year	Hard Copy	Microfiche
1974	---	B0874-005M
1975	B0875-007	B0875-007M
1976	B0876-001	B0876~00lM
1977	B0877-001'	B0877-OOlM
1978	B0878:081	B0878-001M

PREFACE

The REAPS Program is a U.S. shipbuilding industry/Maritime Administration cooperative effort whose goal is the improvement of shipbuilding productivity through the application of computer aids and production technology.

The Sixth Annual REAPS Technical Symposium, held September 11-13, 1979 in San Diego, California, represents one element of the Program which is designed to provide industry with the opportunity to review new developments in shipyard technology. The Symposium was attended by 177 people from 26 different shipyards, 7 government agencies, and 37 other supporting organizations,

We want to express our appreciation to the management of National Steel and Shipbuilding and of Atkinson Marine Corp for allowing symposium registrants to tour their respective facilities, and are particularly indebted to all the people at these organizations who volunteered their time to make these tours so interesting.

The 1979 REAPS Technical Symposium Proceedings contain most of the papers presented at the meeting. The agenda in Appendix A indicates topics and speakers; Appendix 5 is a list of symposium attendees.

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WELCOME

Albert S. Giorgis
Technical Vice-President
National Steel and Shipbuilding Company
San Diego, California

Mr. Giorgis currently has overall responsibility for the Engineering, Material, and Operations Planning Departments at NASSCO in support of corm-mercial and Navy shipbuilding repair.

He holds degrees in electrical engineering from the Navy Postgraduate School in Monterey, California, as well as a degree from the U.S. Naval Academy in Annapolis, Maryland and has completed over 31 years active ser-vice with the Navy, from Midshipman to Captain, where he specialized in marine engineering as an Engineering Duty Officer. His previous experience includes project management, field contract administration, and shipyard planning and production.

I welcome you to San Diego, the nation's finest city. This city and others on the West Coast are growing in prominence as part of the country's shipbuilding and ship repair base. I, for NASSCO, along with Atkinson Marine, welcome you also to visit our shipyards as part of this Technical Symposium. At NASSCO you will see many of the improvements in the physical plant, as we modernized our yard step by step over the last 15 years. At Atkinson Marine you will see a new and modern facility created starting in 1978 which adds yet another dimension in the already competitive ship repairing and ship conversion marketplace within San Diego. You will see at Atkinson Marine Phase I of the building program nearing completion. Phase II which includes a pier and drydock, will commence in 1980.

Over a relatively short period of time, the REAPS Technical Symposium has grown to the stature of an annual event of some prestige. Shipbuilders and others concerned with shipbuilding productivity look forward to this yearly opportunity to exchange information on ongoing research and new developments in the national effort of building ships of consistently good quality in shorter periods of time and at less cost. Toward this goal, there has been an amicable partnership between the old art of shipbuilding and the newer sciences of computer-aided data management.

NASSCO is a participating shipyard in the REAPS Program. Our membership reflects a belief by management that a cooperative effort by many yards with the encouragement and support of the Government is a good way to attack some of the problems that face U.S. shipbuilders. An important element in this arrangement is that research projects performed under the REAPS program are cost-shared with the Maritime Administration. For example, NASSCO has a direct interest in the development of the Computer-Aided Estimating System for Shipbuilding (CAESS), and thus we pursue this project with a certain dedication. Working within the

REAPS framework allows for input from other shipyards with the same interests and assures that the finished product as demonstrated and delivered will be useful to all U.S. shipyards. Seeing the promise of success in this methodology, NASSCO is proposing another project for "Space Arrangements Using Interactive Graphics".

As you can see from the agenda, the REAPS Technical Symposium covers a very broad range of interests, many of which are computer-oriented. Computer applications are found in every department of the shipyard and in the operations of everyone that we do business with. A ship that was once a hand-crafted product is now a child of sophisticated parents, moving all the way from inception to sea trials with the help of the computer. Shipyards now have large computer departments, and I suppose it would be easy to fall into the trap of working for the computer.

At NASSCO, we have a sizeable Information Systems Department which gets involved in all phases of the business, including technical, management and production. Computer systems are a part of information systems, whose sole reason for existence is to act as a service to the functional departments of the company. Thus,a computer system is devised in response to an expressed need in a certain functional area after a study indicates that the proposed project would be cost effective. I know that REAPS projects, too, must be shown to be able to yield cost benefits before they are authorized.

Research projects to improve productivity need not necessarily be computer-oriented. I am happy to see that a number of papers to be presented dwell on other aspects of the problem. Topics such as labor productivity, outfit planning, and production engineering are fertile areas where thoughtful investigation should bear good fruit. In this connection the ongoing tranfer of technology at Levingston Shipbuilding, of which you will hear more during this symposium, is, in my opinion, of vital interest to the whole shipbuilding community. Because the management of

NASSCO believes that productivity improvements are vital to and may well determine the success of the company in the future, NASSCO has embarked on a technology transfer of somewhat lesser scope. Our visits to foreign shipyards and their visits to our shipyard have produced an awareness of the need to improve in our ability to pattern work to the capabilities of the workforce, to accomplish work under the most favorable and efficiency - producing conditions and to realize that the continuing rationalization of the shipbuilding process is severely hampered if information feedback is not an integral part of all phases of shipbuilding. The topic of Outfit Planning on Wednesday morning will, in part, provide an indepth discussion of what I have only briefly touched on. It doesn't take much imagination to see where the computer plays an increasingly important role in the feedback system. The Japanese shipbuilder is continually seeking methods at all levels of the workforce to simplify what he is doing as a means to improve efficiency whether it be fabricating steel piece-parts, designing or assembling complex structures and *systems*. When you realize that this *is* done *to* improve the capability to build faster and cheaper at no sacrifice to quality with a workforce that on the average has fourteen to fifteen years experience in shipbuilding you can grasp as I'm sure, the majority of you already have the scope of the problem we shipbuilders face. What is the average experience level of your workforce?

Success of this symposium is assured through the cross section of affiliations of the authors of the papers. The range is from shipbuilders *to* academia, and from users to suppliers of system hardware and software. As you can see, the program attracted a large number of registrants which speaks well for the symposium planners.

I bring you NASSCO's greetings and I give you my best wishes for a meaningful three-day experience.

THE REAPS PROGRAM: AN OVERVIEW AND STATUS

James R. Vander Schaaf
Senior Naval Architect
IIT Research Institute
Chicago, Illinois

Jim Vander Schaaf is currently responsible for the development, training and application of several REAPS CAD/CAM products. He holds degrees in aerospace engineering, naval architecture and marine engineering from the University of Michigan, and a degree in computer science from Johns Hopkins University.

His past experience has concerned the development and application of various computer-aided ship design and construction applications in use in government and industry.

REAPS, an acronym for Research and Engineering for Automation and Productivity in Shipbuilding, is an industry/government cooperative program for enhancing U.S. shipbuilding production through development and implementation of computer aids and manufacturing technology.

PROGRAM ACTIVITIES - The primary thrust of the REAPS Program is the conduct of research and development projects for a variety of design and production processes in the shipyard. Such projects are initiated and pursued only upon consensus of the participating yards and are not considered complete or successful until they have been implemented under actual shipyard production conditions. Other services for its participants include:

- Technology Assessment - Periodic appraisals of the latest technologies in a variety of industries for application to current problems in U.S. shipbuilding processes.

- Technical Support - Technical assistance to participating yards in implementation, use, modification, and maintenance of REAPS developments.

- Technical Information Services - Through the REAPS Shipbuilding Technology Library an extensive collection of related literature and computer software is made available to the participating yards.

Additional REAPS services provided to the entire shipbuilding community include:

- REAPS Technology Bulletin - A periodic synopsis of articles appearing in world-wide publications, of interest to the REAPS community. REAPS participants may order copies of cited articles free of charge; others at cost.

- REAPS Technical Symposium - An annual symposium providing the industry with a single forum for gathering information through formal technical presentations on the state of the art. All are invited; REAPS yards attend at reduced rates.

REAPS PROJECTS - REAPS-sponsored projects are initiated and pursued under the following scenario:

- The participating yards:
  - Identify common problem areas
  - Recommend specific R&D projects to address these areas
  - Monitor on-going projects

- The U.S. Maritime Administration (MarAD)
  - Contracts with REAPS yards on a cost-sharing basis for the development projects

- The IIT Research Institute (IITRI)
  - Serves as Technical Manager
  - Provides technical and administrative services for the REAPS yards and MarAd to assure smooth functioning of the program
  - Conducts selected developments specified by the REAPS yards

Current project status is summarized in Table 1. Previous projects are summarized in Table 2. Project deliverables (software, documentation and reports, etc.) are distributed to all interested REAPS participants free of charge.

ORGANIZATION - Personnel from each of the REAPS yards participate in:

- The Executive Committee - Meets at least once a year to 'develop program policy and direction.

- The Technical Representatives - Meet at least four times a year to make project recommendations and to direct the conduct of the program.

- Advisory Groups - Provide technical guidance to developers on specific projects - established for each major development activity.

FUNDING - Funding for development projects is derived from MarAd cost-sharing contracts with individual yards. Funding for the Technical Manager to conduct the REAPS Program itself is provided by MarAd and supplemented by annual yard participation fees.

COST - For the current program, the annual fee for full participation was $10,000; the associate participation (non-voting participation available only for the first year) fee was $5,000.

CURRENT PARTICIPANTS - The following shipyards are participating in the 1979 REAPS program:

- BATH IRON WORKS
- BETHLEHEM STEEL
- GENERAL DYNAMICS
- J. MY McDERMOTT
- NATIONAL STEEL
- NEWPORT NEWS SHIPBUILDING
- PETERSON BUILDERS
- SUN SHIPBUILDING

PROCEDURE FOR BECOMING A REAPS PARTICIPANT - Joining the REAPS Program requires the execution of a REAPS Agreement, a contractural agreement between your organization and the IIT Research Institute, the REAPS Technical Manager. At present, membership is restricted to U.S. shipbuilding firms.

FOR MORE INFORMATION - Contact the

REAPS Program Manager
10 West 35th Street
Chicago, Illinois 60616
312/567-4618

TABLE 1

CURRENT REAPS PROJECTS

PROJECT	DESCRIPTION	SPONSOR	SCHEDULED COMPLETION	IMPLEMENTATION FOLLOW-ON
PIPE DETAILING (RAPID) SYSTEM	Minicomputer-based system for digitizing piping systems to produce fabrication instructions, bill of materials and shop sketch	NNS&DD	DEC 979	Workshop Oct. 1979
PARTS DEFINITION SYSTEM	Develop an interactive graphics system to support the definition of structural parts at a CRT, interactive nesting and the generation of shop drawings.	NNS&DD	MID 1981	
COMPUTER ASSISTED COST ESTIMATING	Develop an estimating methodology which makes use of computer assistance and demonstrate its feasibility	NASSCO	MAY 1981	
PRODUCT INFORMATION SYSTEM TASK 1: STRUCTURAL INFORMATION REQUIREMENTS SPECICATION	Develop a list of information requirements dictated by engineering, design, planning, and production functions in shipbuilding as regards structure which will be used in the design of a structural database.	IITRI, NNS&DD, BATH, PETERSON	APRIL 1980	
INTEGRATED HULL FORM DESIGN	The objectives of Phase I are to collect, implement, distribute, and maintain existing computer aids which meet REAPS yards requirements in the area of early hull form design	IITRI	APRIL 1980	

TABLE 2

PREVIOUS COMPLETED REAPS PROJECTS

PROJECT	DESCRIPTION	SPONSOR	DATE COMPLETED	IMPLEMENTATION FOLLOW-ON
DAMAGED STABILITY PROGRAM	Develop and document computer programs to perform damaged stability analysis of ship and non-ship forms	BETHLEHEM	JULY 1977	Workshop Dec. 1977. Used in production at Beth Ship. Ordered by others.
COLD TWIST FORMING OF STRUCTURAL SHAPES	Demonstrate the feasibility of twisting structural shapes cold, using inexpensive dies in a hydraulic press.	IITRI	MARCH 1978	Full capability being fabricated at NNS for production use.
HULL DEFINITION FAIRING (HULDEF) PROGRAM	Adapt to commercial use and document a Navy-developed program for hull surface definition and fairing	NNS&DD, Contractor, MARAD, NAVY, IITRI	MAY 1978	Workshop August 1978 Used in production at NNS&DD, Sun Ship, Peterson, McDermott, GD. Ordered by others.
GRAPHICS AND COMMUNICATIONS TERMINAL	Develop software to allow minicomputer-based system to concurrently verify N/C "tapes" and perform remote computer communications.	IITRI	NOV. 1978	Installed for production use at Beth. Ship.
N/C FRAME BENDING MACHINE	Develop and demonstrate a fully automated CNC frame bending machine	MARAD/ NSF/NAVSEA/ CONTRACTOR	OPERATIONAL MACHINE- JULY 1978	Full capability under installation at NASSCO

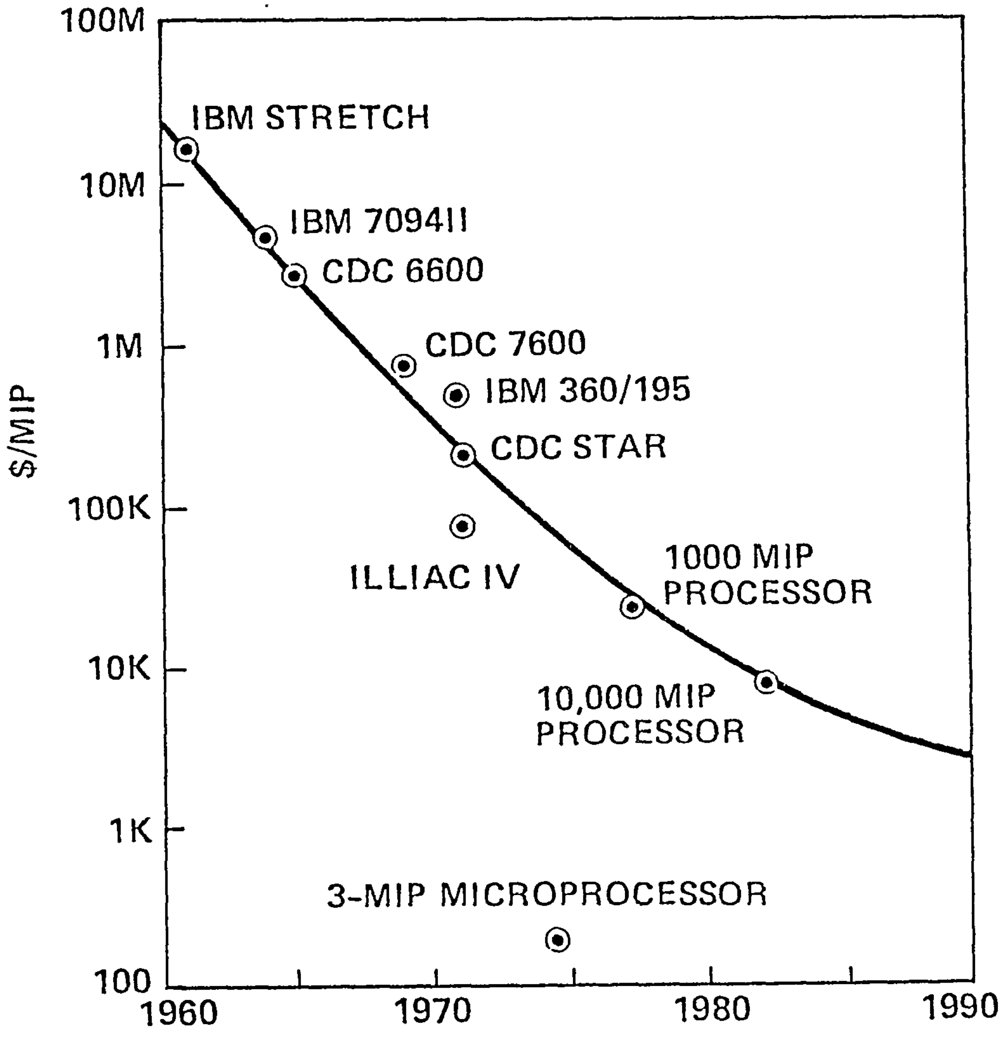
ALTERNATIVES FOR EFFECTIVE CAD/CAM UTILIZATION

Bernard J. Breen
Corporate Manager, CAD/CAM
General Dynamics Corporation
Data Systems Services
St, Louis, Missouri

As Corporate Manager, Mr. Breen is currently responsible for corporate reporting of CAD/CAM activities, directing tactical and strategic CAD/CAM planning, and ensuring high productivity gains through CAD/CAM implementations for General Dynamics Corporation.

Mr. Breen is a graduate of Purdue University with a degree in mathematics. In the past, he has been responsible for implementing automated tools for shipbuilding disciplines, and instrumental in initiating early REAPS program activities. He has been involved in the implementation of interactive graphics, DNC/CNC, group technology, photogrammetry, robotics and automated inspection systems in Electronics, Aerospace and Shipbuilding industries.

SYSTEM COST PER MILLION INSTRUCTIONS PER SECOND (MIPS)



CAD/CAM PURPOSE:

DATA CONFIGURATION CONTROL

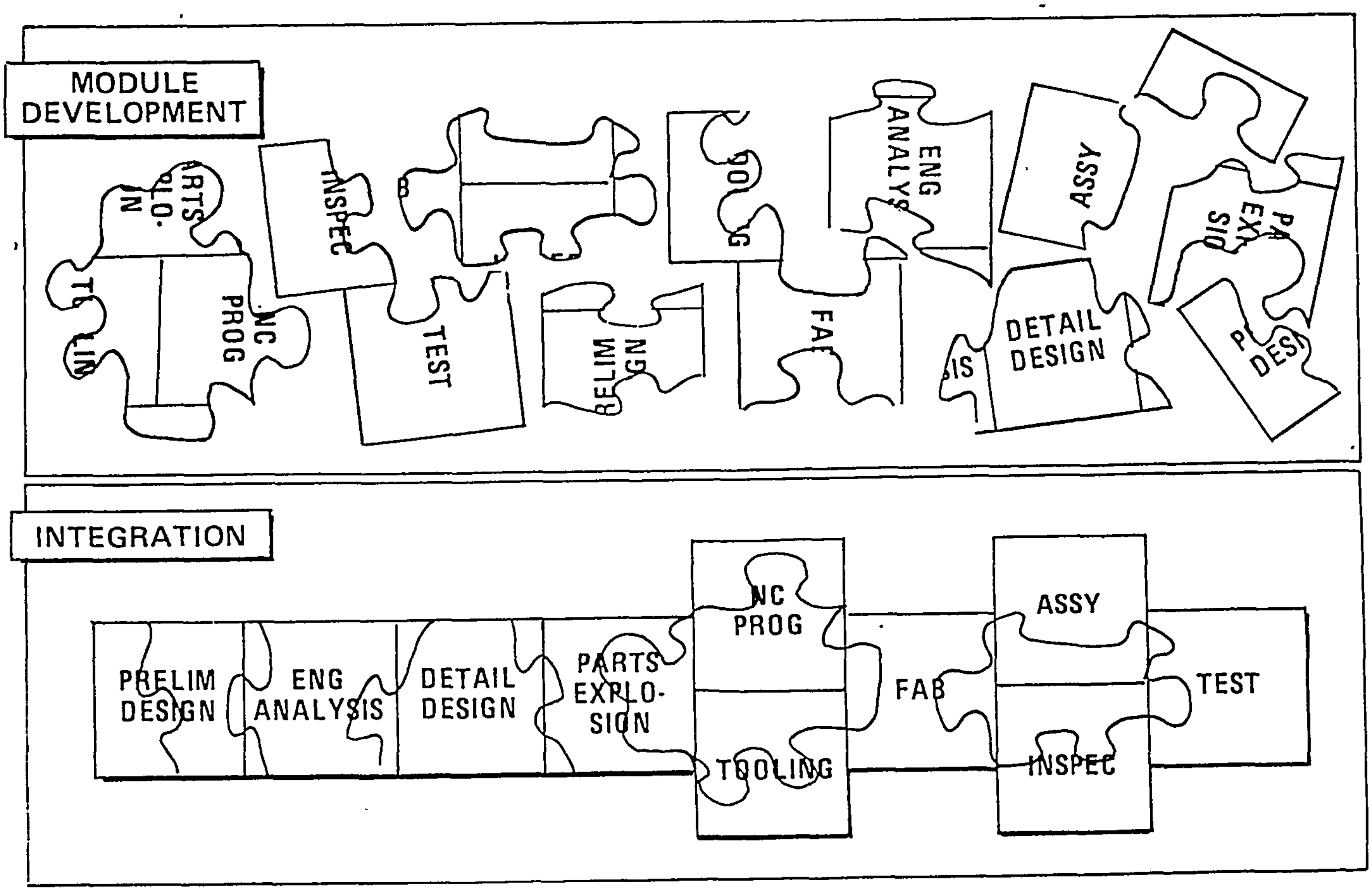
- AS DESIGNED
- AS BUILT
- REVISION/CHANGE
- STATUS

CAD/CAM OBJECTIVE:

INCREASED PRODUCTIVITY

- REDUCED SCHEDULE
- REDUCED MANHOURS
- BETTER DESIGN
- BETTER MATERIAL UTILIZATION
- BETTER RESPONSIVENESS TO CHANGE
- LOWER COST

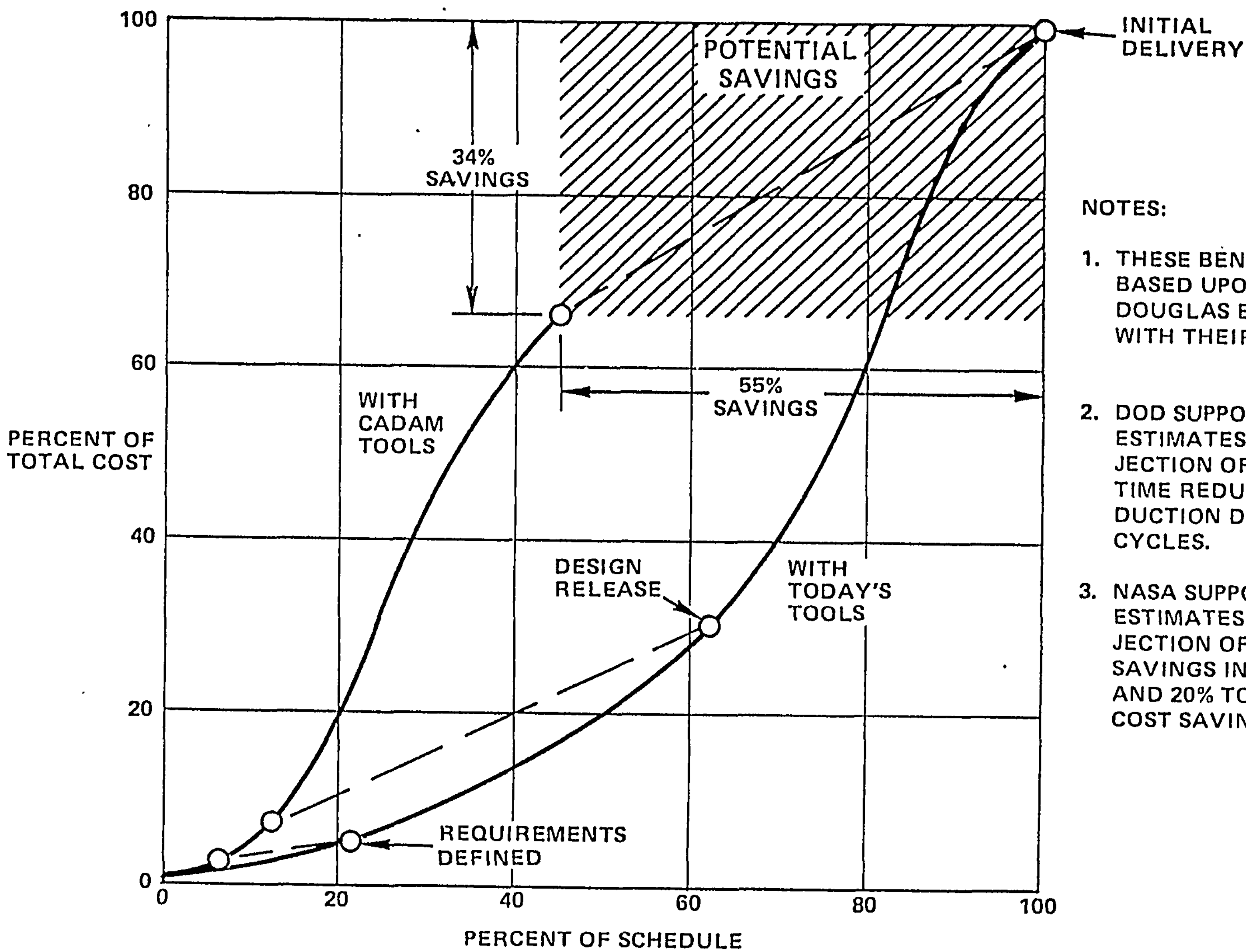
GOAL: INTEGRATED SYSTEM



FORECASTED EVENTS IN THE DEFENSE INDUSTRY ARE:

- FEASIBILITY DEMONSTRATION OF THE DESIGN AND MANUFACTURE OF PRINTED CIRCUIT BOARDS AND MECHANICAL PARTS WITHOUT GENERATING AN ENGINEERING DRAWING OR ANY OTHER PAPER DOCUMENT IN AT LEAST FIVE OF THE MAJOR DEFENSE COMPANIES BY 1979
- ROUTINE USE OF INTEGRATED CADAM TOOLS ON 50 PERCENT OF NEW PRODUCT DESIGNS IN THE DEFENSE INDUSTRY BY 1982
- ELIMINATION OF THE DRAWING (PAPER DOCUMENTATION) AS A MEANS OF TRANSMITTING ENGINEERING DESIGN TO MANUFACTURING IN 50 PERCENT OF DEFENSE PLANTS BY 1985
- UP TO 55 PERCENT REDUCTION IN DEVELOPMENT SCHEDULE (GO-AHEAD TO PROTOTYPE DELIVERY) AND UP TO 37 PERCENT REDUCTION IN PROTOTYPE DEVELOPMENT COSTS ROUTINELY ACCOMPLISHED IN 50 PERCENT OF THE DEFENSE INDUSTRY BY 1987

CAD/CAM POTENTIAL SAVINGS



NOTES:

1. THESE BENEFITS ARE BASED UPON McDONNELL DOUGLAS EXPERIENCE WITH THEIR CAD SYSTEMS
2. DOD SUPPORTS THESE ESTIMATES WITH A PROJECTION OF A 5:1 AVERAGE TIME REDUCTION IN PRODUCTION DEVELOPMENT CYCLES.
3. NASA SUPPORTS THESE ESTIMATES WITH A PROJECTION OF 25% TO 90% SAVINGS IN FLOWTIME AND 20% TO 60% TOTAL COST SAVINGS.

DEVELOP vs PROCURE

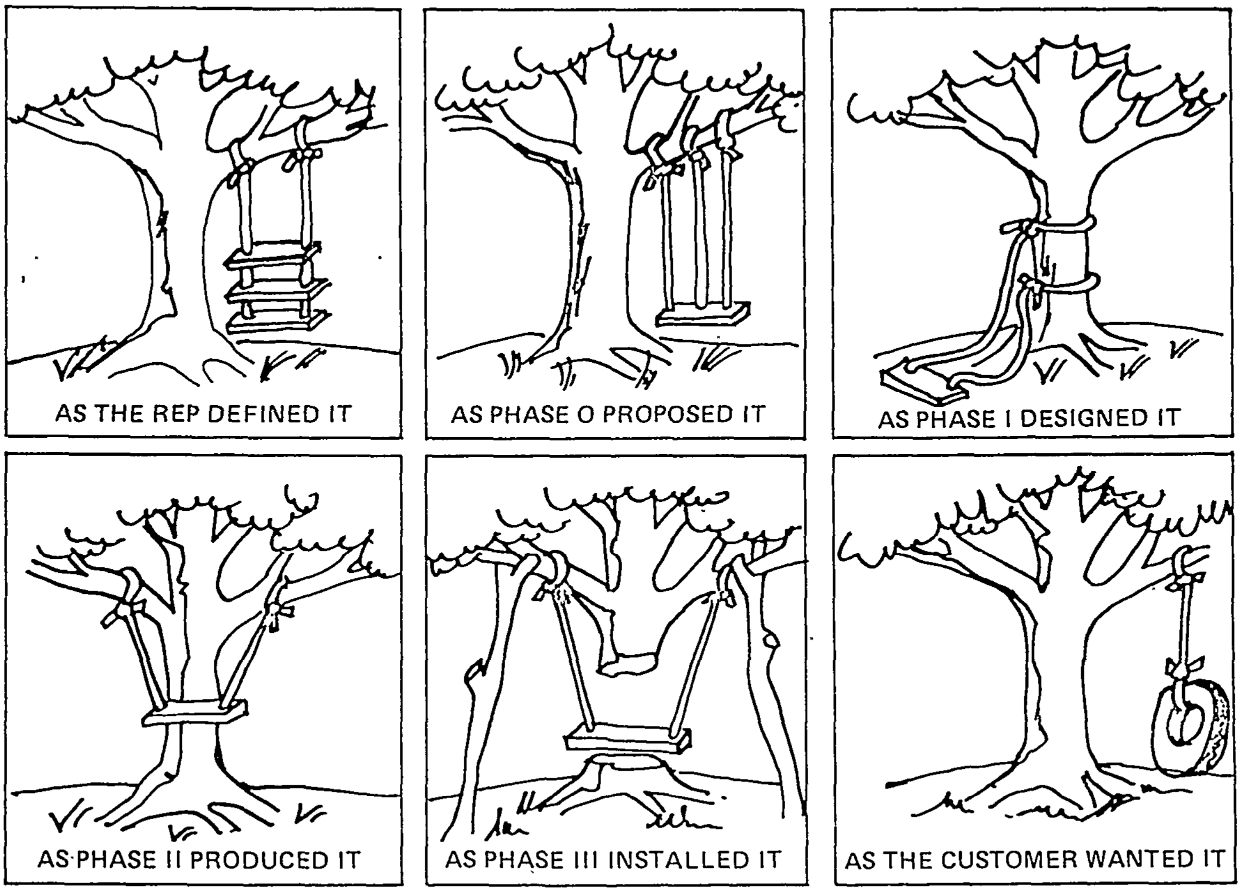
• TOTAL SYSTEM NOT "OFF THE SHELF"

•SYSTEM ELEMENTS ARE AVAILABLE

•DEVELOPMENT COSTS EXCEED PROCUREMENT COSTS

•DEPENDENCE ON SUPPLIERS

•INTEGRATION OF PROCURED ELEMENTS



M A I N T A I N

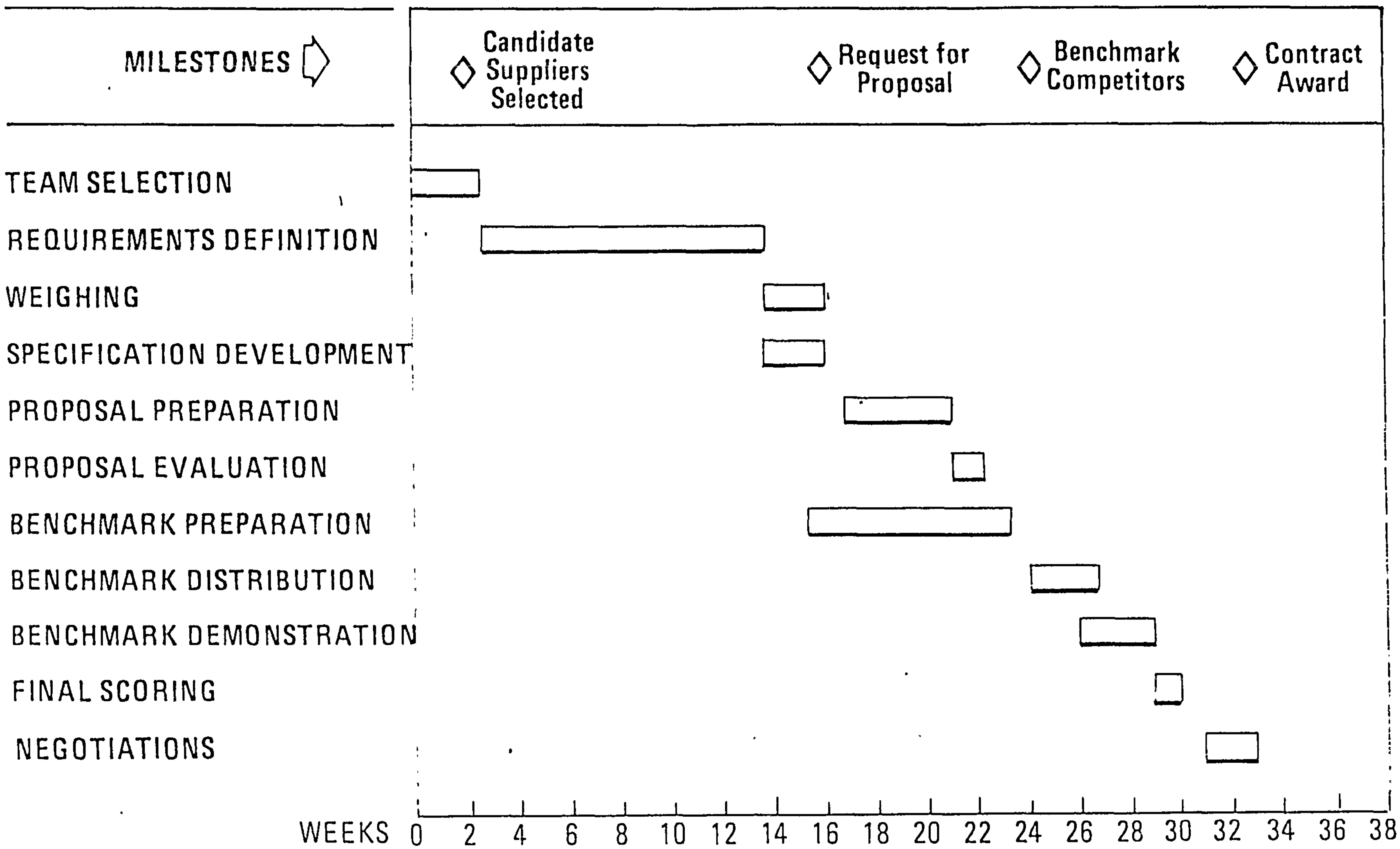
O B J E C T I V I T Y

I N T E R A C T I V E G R A P H I C S

K e y E l e m e n t s

- P R I N T E D C I R C U I T E L E M E N T S
- I N T E G R A T E D C I R C U I T D E S I G N
- E L E C T R I C A L S C H E M A T I C S
- A R T W O R K
- S T R U C T U R A L D E S I G N
- M E C H A N I C A L D E S I G N
- D R A F T I N G
- N E S T I N G
- N U M E R I C A L C O N T R O L
- P I P I N G L A Y O U T

SCHEDULE


MILESTONES
Candidate Suppliers Selected
Request for Proposal
Benchmark Competitors
Contract Award
TEAM SELECTION
REQUIREMENTS DEFINITION
WEIGHING
SPECIFICATION DEVELOPMENT
PROPOSAL PREPARATION
PROPOSAL EVALUATION
BENCHMARK PREPARATION
BENCHMARK DISTRIBUTION
BENCHMARK DEMONSTRATION
FINAL SCORING
NEGOTIATIONS
WEEKS 0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38

FUNCTIONAL/TECHNICAL SPECIFICATION

Major Areas

- APPLICATION REQUIREMENTS
- SYSTEM SOFTWARE REQUIREMENTS
- HARDWARE REQUIREMENTS
- RELIABILITY AND MAINTENANCE
- DOCUMENTATION
- SOFTWARE SUPPORT
- HUMAN FACTORS (Environment)
- BENCHMARK
- ACCEPTANCE TESTS

CAD/CAM REQUIREMENT:

MANAGEMENT COMMITMENT

- PLANNING
- JUSTIFICATION
- TRACKING
- MEASUREMENT

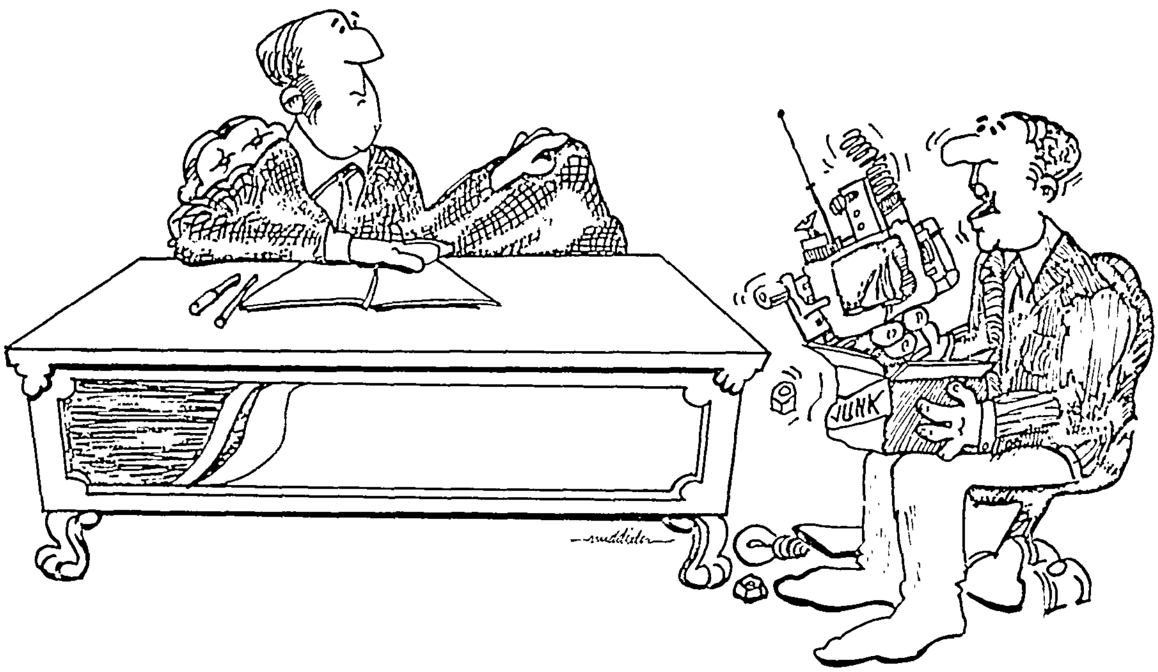
RECOMMENDED STRATEGY:

IDENTIFY REQUIREMENTS

IMPLEMENT EXISTING TECHNOLOGY

SUPPORT RESEARCH AND DEVELOPMENT

GENERAL DYNAMICS
Data Systems Services



"We don't have your system designed yet, but I brought along what we have."

DS2969

THE SHIPBUILDING TECHNOLOGY TRANSFER PROGRAM

Robert R. Roper
Technology Transfer Program Coordinator
Levingston Shipbuilding Company
Orange, Texas

Mr. Roper has a degree in liberal arts from the University of Colorado. His current responsibilities include direction of program studies and reports; and the implementation of recommended changes. He is also in charge of MarAd reports,presentations and industry seminars.

Mr. Roper has previously served as Director of Business Development for Ingalls Shipbuilding, and President of Paden-Roper Associates, Inc, management consultants. He has more recently completed a two-week tour and study of shipyards in Japan.

One of the most innovative ideas to come along in the shipbuilding industry in a very long time is the one that inspired the Shipbuilding Technology Transfer Program (TTP). The idea evolved from a long and tedious, but finally successful, attempt by Levingston Shipbuilding Company (LSCo) to secure a contract for the construction of five 36,000 DWT dry bulk carriers. These ships were to be built to a modified design of the Future-32 class ships previously designed and built by Ishikawajima-Harima Heavy Industries (IHI) of Japan.

Because the design was to be modified to provide two medium-size diesel engines instead of the single engine in the original design, Levingston contracted with IHI for on-site design engineering support. It was at this point when the idea of transferring Japanese production technology occurred to the Levingston management.

The American shipbuilding industry is well aware of the significant cost differences between the Japanese and ourselves. Many reasons have been offered to explain this differential and whether the reasons are valid or not, the fact remains that Japanese yards are consistently able to offer ships at a price one-half to two-thirds below American prices. Obviously, these Japanese companies are also making a profit and doing it without benefit of government subsidy.

Seeing this tremendous difference firsthand in their own estimate of the slightly modified bulkers, Levingston management decided to not only find out why but to attempt to determine precise differences between IHI and LSCo engineering and design practices; production planning and control methods; facilities, production processes, methods and techniques; quality assurance methods; and personnel organization, operations, and training. The obvious objective of such studies was to identify, examine and implement the Japanese systems, methods and processes which appeared to be applicable to Levingston and which promised a significant improvement in the LSCo design/production process.

With this objective in mind, LSCo initiated a subcontract with IHI Marine Technology Inc. (an American corporation) specifying the areas to be explored and the number and types of IHI consulting personnel required during the period of re-design and initial construction of the first bulkers.

Subsequently, recognizing the potential application of TTProgram results to the American shipbuilding industry, LSCo initiated a cost-sharing contract with MarAd to provide documentation and industry seminars to reveal program findings and production improvement results measured during production of the bulkers.

The program is now into its 11th month of operation. IHI consultants have worked side-by-side with LSCo personnel in virtually every area of ship design and construction. The program is precisely organized to: 1) study IHI systems, methods and techniques; 2) compare the LSCo and IHI practices; 3) identify improvements to the LSCo systems; 4) implement approved changes, and 5) document program findings, changes to the LSCo systems, and the results of those changes.

Basically, the program is organized into six major task areas:

1 - Cost Accounting
2 - Engineering and Design
3 - Planning and Production Control
4 - Facilities and Industrial Engineering
5 - Quality Assurance
6 - Industrial Relations
(See Figure 1)

Beneath each of these major tasks are a series of sub-tasks which further delineate discrete areas of investigation and study. These sub-task areas are shown in Figures 2 through 7.

A task leader and a task coordinator is assigned to each major task area. These personnel are directed by means of work orders, schedules and standard procedures from the Technology Transfer Program Office at Levingston. IHI consultants are assigned by a resident IHI Program Manager to each of the task areas as required by workload and program schedules.

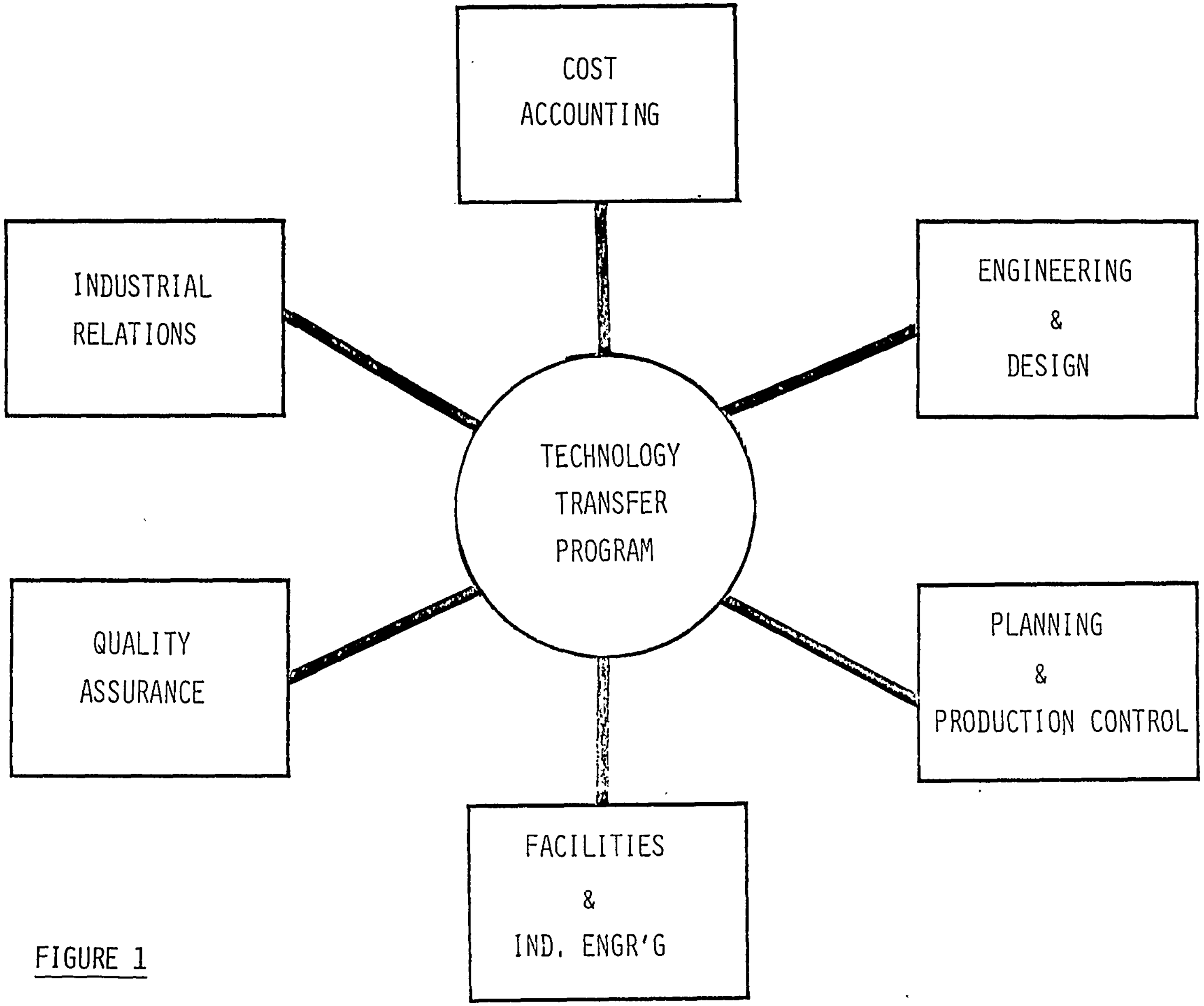
Program activities have increased from a beginning manpower level of three to a maximum of twenty people full-time dedicated to Technology Transfer. As the program accelerated in the first few months, the full potential of the program became manifest but the detail study and assimilation of the Japanese concepts and practices was, and at this writing still is, a tedious process. Significant findings in each task area have

been obtained and some of these findings are being applied to the Levingston production system. Implementation of accepted changes is now occurring in production planning and control; facilities and equipment; design, material, tolerance, welding and process standards; production processes and methods; and quality assurance. Of course, both the implementation of the new systems and methods and the measurement of their effectiveness will take time. The fact that these changes are occurring simultaneously with a five-ship new construction program compounds the problems ordinarily attendant to any first-of-a-kind new ship program. However, the transfer of this technology is proceeding and ultimately promises beneficial and profitable results.

At the start of the bulker program, the Levingston workforce numbered approximately 1,200. Now, some eleven months later, the workforce is at 1,650. The rapid increase and assimilation of new employees; the study, implementation and assimilation of new systems, processes, methods and techniques; and the construction of a class of five new ships is an ambitious and difficult task for any shipyard. But the potential benefits, both immediate and long range, diminish the difficulty of the undertaking into virtual obscurity. Levingston management is as dedicated to the program as ever, perhaps even more than at its inception. And, gradually, as the program accelerates, the yard workforce is recognizing and accepting benefits of Technology Transfer.

As part of its contract with MarAd, Levingston will present three industry seminars to provide details of its findings, system improvements and results as the program evolves.

From its inception and now, from a point approximately a third of the way through the program, the prospect of extraordinary success of the Technology Transfer Program appears certain both for Levingston and for American shipbuilding in general.


COST
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&
DESIGN
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TRANSFER
PROGRAM
QUALITY
ASSURANCE
PLANNING
&
PRODUCTION CONTROL
FACILITIES
&
IND. ENGR'G

FIGURE 1

TASK 1 - COST ACCOUNTING

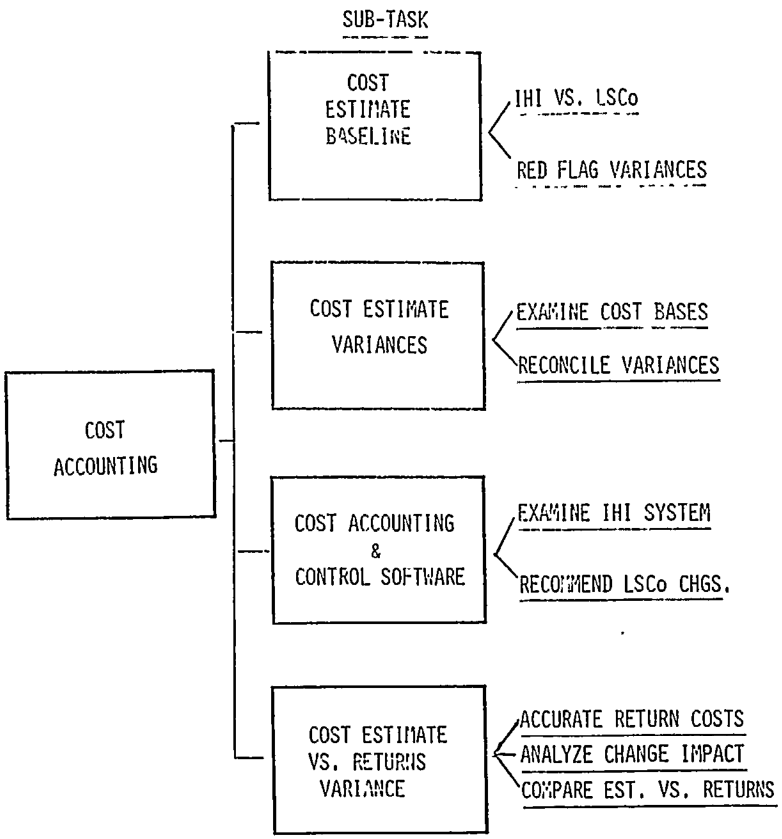

FIGURE 2

TASK 2 - ENGINEERING & DESIGN

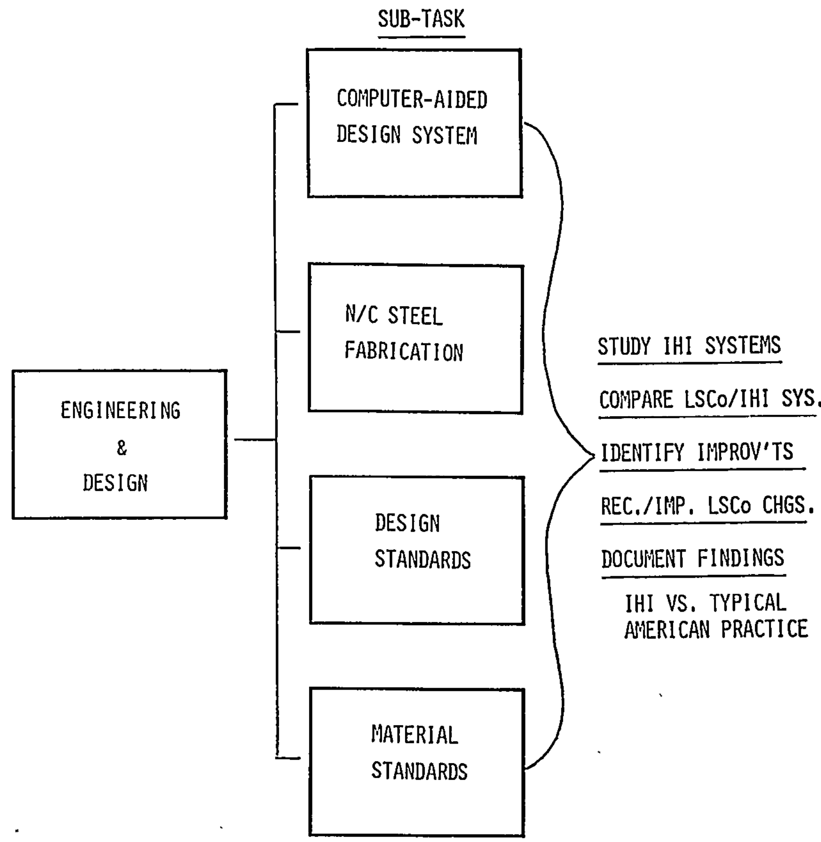

FIGURE 3

TASK 3 - PLANNING & PRODUCTION CONTROL

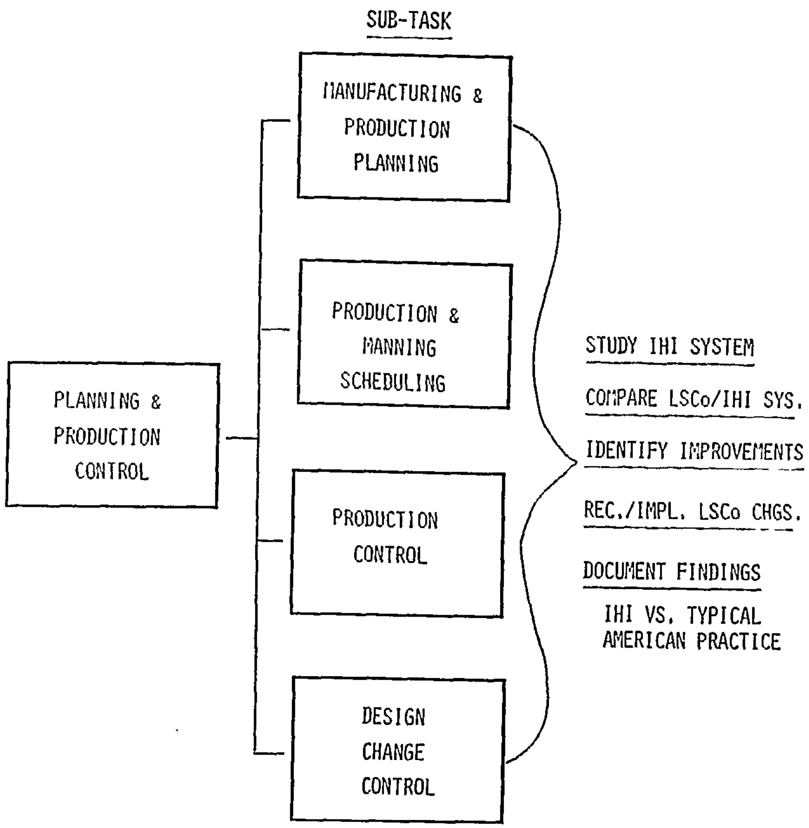

FIGURE 4

TASK 4 - FACILITIES & INDUSTRIAL ENGINEERING

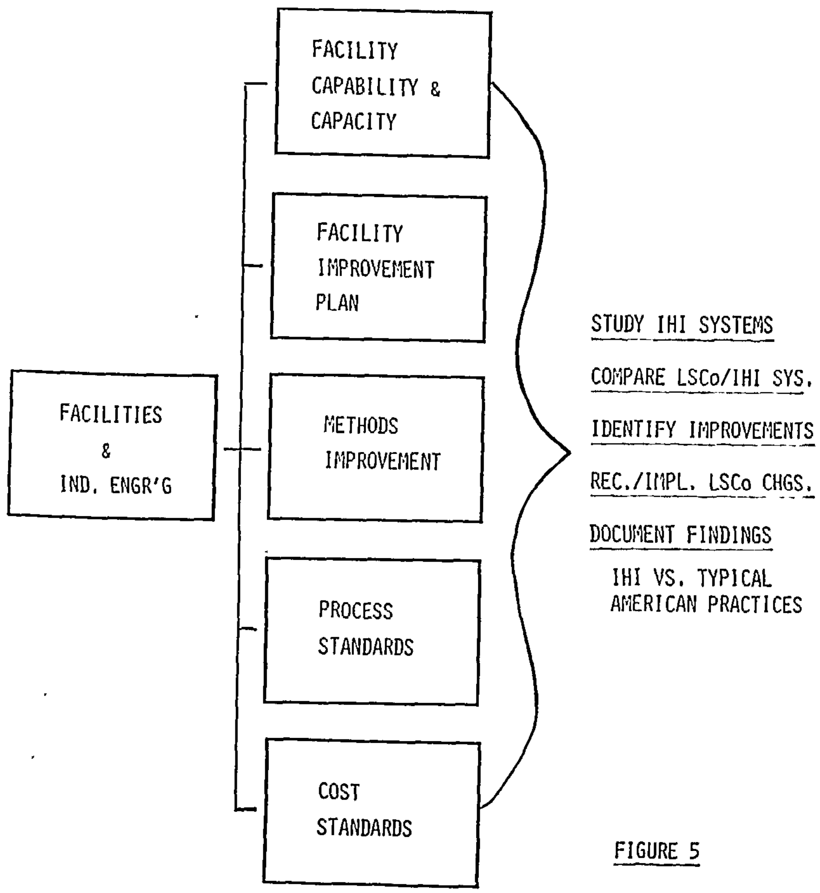

FIGURE 5

TASK 5 - QUALITY ASSURANCE

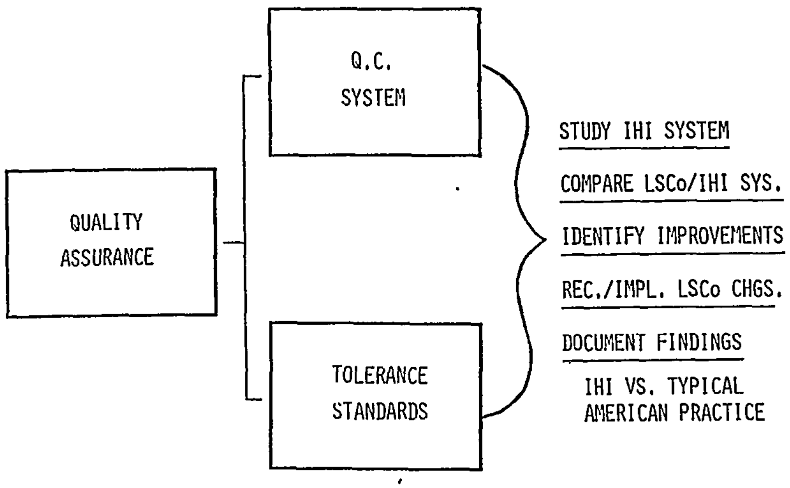

FIGURE 6

TASK 6 - INDUSTRIAL RELATIONS

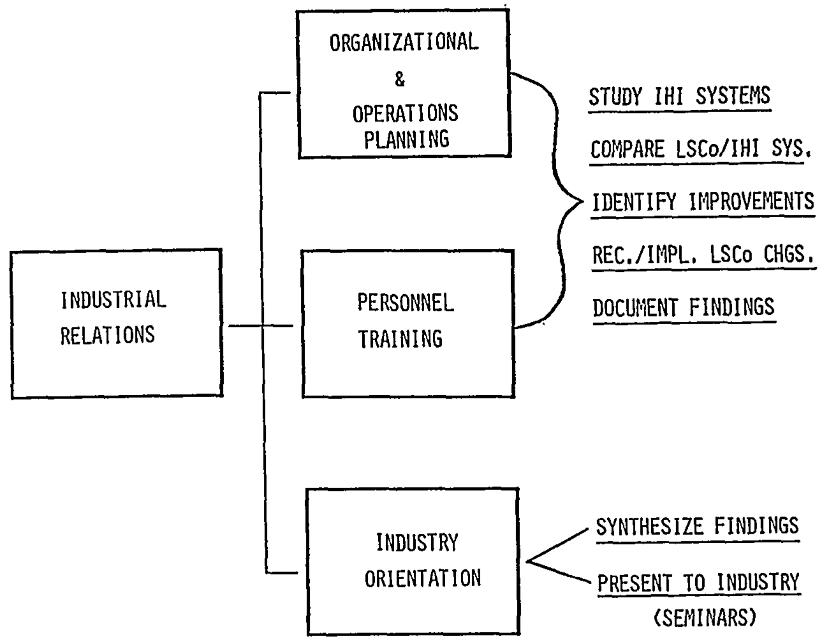

FIGURE 7

SIGNIFICANT FINDINGS TO DATE

PRODUCTIVITY VARIANCES ATTRIBUTABLE TO:

PERSONNEL

WORKER ATTITUDES - TENURE - LABOR/MANAGEMENT RAPPORT

FACILITIES

HIGHLY PERFECTED FOR ALL OPERATIONS

SUPERIOR APPLICATION OF TECHNOLOGY

SYSTEMS

INTEGRATED ENGR'G/PLANNING PRODUCTION SYSTEMS

IDENTIFIABLE RESPONSIBILITY AT ALL LEVELS

EXTENSIVE USE OF SUBCONTRACTORS

SIGNIFICANT FINDINGS TO DATE

COST VARIANCES ATTRIBUTABLE TO:

- HIGHLY AUTOMATED DESIGN/PRODUCTION SYSTEMS
- HIGHLY DEPENDABLE/EXPERIENCED WORK FORCE
- "FAMILY" OF SUBCONTRACTORS
- SERIES PRODUCTION W/MIN, CHANGE
- ACCOUNTING PRACTICES

SIGNIFICANT FINDINGS TO DATE

ENGINEERING & DESIGN

- FULL UTILIZATION OF COMPUTER-AIDED DESIGN SYSTEM
- HIGHLY PERFECTED DESIGN STANDARDS
- PRODUCTION ENGINEERING/PLANNING BY WORKSHOP STAFF
- ENGINEERING PERSONNEL AT ALL LEVELS

SIGNIFICANT FINDINGS TO DATE

PLANNING & PRODUCTION CONTROL

- LONG LEAD TIME FOR PLANNING (7 MOS.)
- DECENTRALIZED ENGR'G & PLANNING FUNCTIONS
- DETAIL PLANNING/SCHEDULING AT EVERY LEVEL
  - HEAD OFFICE
  - YARD PRODUCTION CONTROL
  - ENGINEERING/PLANNING STAFFS
  - FOREMEN
- STANDARDIZED METHODS/PROCESSES

SIGNIFICANT FINDINGS TO DATE

FACILITIES

' OPTIMUM MATERIAL FLOW & CONTROL

' "PROCESS LANES" CONCEPT

' PERFECTED OVER 30 YEARS

GOVERNMENT LOW COST LOANS
TAX BENEFITS
INTEREST SUBSIDIES
PLANT IMPROVEMENT SUBSIDIES

' EXCELLENT MAINTENANCE/CLEANLINESS

SIGNIFICANT FINDINGS TO DATE

INDUSTRIAL ENGINEERING

' HIGH UTILIZATION OF:

STANDARDS, JIGS & FIXTURES
MOVABLE PLATFORMS/SCAFFOLDING
HEAVY-LIFT CRANES
PALLETS
STANDARD METHODS/PROCESSES

' CONTINUING FACILITY/METHODS IMPROVEMENT

SIGNIFICANT FINDINGS TO DATE

QUALITY ASSURANCE

- ACCURACY CONTROL DIRECTS & CONTROLS ALL FUNCTIONS
- Q.C, PERFORMS MEASUREMENTS OF VITAL POINTS/DIMENSIONS
- "SELF-CHECK" SYSTEM
  - GROUP CHECKER
  - ASSISTANT FOREMAN
  - Q.C,
- EMPHASIS ON PEOPLE ⟶ QUALITY

SIGNIFICANT FINDINGS TO DATE

INDUSTRIAL RELATIONS

- PERSONNEL WELFARE IS ALL-IMPORTANT
- COOPERATIVE LABOR/MANAGEMENT ATTITUDE
- WORKER SAFETY IS PRIMARY CONCERN
- PERSONAL PRIDE IN WORKMANSHIP
- GROUP VS. INDIVIDUAL PERFORMANCE
- FRINGE BENEFITS - 60 TO 70%
- LIFE-TIME CONTRACT
- RECIPROCAL WORK ETHIC

KEYS TO HIGHER PRODUCTIVITY

1, WORKER ATTITUDES:

LOYALTY - DEPENDABILITY

WORKMANSHIP - DEDICATION

2, BALANCED-INTEGRATED DESIGN/PRODUCTION SYSTEM

3, SUPERB FACILITIES/EQUIPMENT

4, LABOR RELATIONS

5, PLANNING - PLANNING - PLANNING

6, GROUP IDENTITY

NAVY MANUFACTURING TECHNOLOGY PROGRAM

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Mr. Carstater holds a degree in chemical engineering from Bucknell University, and has an extensive background in Navy weapons manufacturing technology at field and managerial levels.

Prior to his present position, Mr. Carstater was Director of Advanced Products and Processes at the Naval Ordnance Station, Indian Head, Maryland. He earlier held several project engineering and program manager positions, principally in missile propulsion, explosives, and specialty chemical processing.

Mr. Carstater received the Meritorious Civilian Service Award in 1975 for his role in the scale-up and pilot processing of critical rocket fuels.

GOOD MORNING, I'M PLEASED TO HAVE BEEN ASKED TO SPEAK TO YOU TODAY ON THE NAVY'S MANUFACTURING TECHNOLOGY PROGRAM, I SAY THIS:

- NOT ONLY BECAUSE YOUR'E A GROUP OF CONCERNED CITIZENS INTERESTED IN THE FUTURE OF SHIPBUILDING IN THE U, S, AND MT SHARES IN THIS INTEREST, AND
- NOT ONLY BECAUSE SHIPBUILDING IS A TOPIC OF NATIONAL PROMINANCE IN REGARD TO PRODUCTIVITY AND ITS IMPACT ON THE ECONOMY - AND THAT ALSO IS OF INTEREST IN THE MT PROGRAM
- BUT, PRIMARILY, I'M PLEASED BECAUSE YOU HAVE DISPLAYED THIS INTEREST IN OUR PROGRAM AND WHAT IT IS ABOUT, AND THIS INDICATES A WILLINGNESS TO WORK TOWARD FULLFILLING OBJECTIVES IN THESE AREAS.

HAVING SAID THIS, I WON'T TRY TO CONVERT you ALL INTO MT SUPPORTERS, BUT I WILL SIMPLY GIVE YOU AN OVERVIEW OF THE NAVY PROGRAM IN GENERAL - AND IT WILL NOT BE A "SHIPYARD ONLY" VIEW, I WILL BE TALKING TO THESE TOPICS:

- THE MT PROGRAM, INCLUDING OBJECTIVES, ORGANIZATION AND PROCEDURES
- PROGRAM HIGHLIGHTS
- COMPLETED STUDIES
- TECHNOLOGY TRANSFER AND
- PROGRAM OUTLOOK

M T P R O G R A M

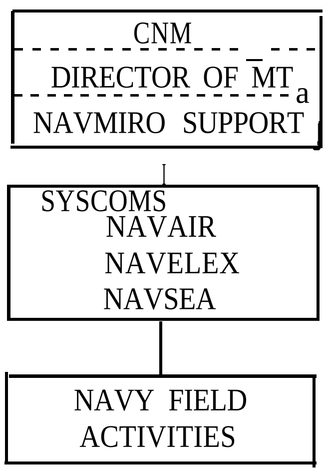
BRIEFING CONTENT

- MT PROGRAM
- FUNDING PROFILE
- FY79 HIGHLIGHTS
- COMPLETED STUDIES
- TECHNOLOGY TRANSFER
- FY80 OUTLOOK
- THRUSTS/INTERESTS
- SUMMARY

OBJECTIVES

- LOWER ACQUISITION COSTS
- SUPPORT NAVY NEEDS
- INCREASE PRODUCTIVITY
- NEW TECHNOLOGY IMPLEMENTATION

ORGANIZATION



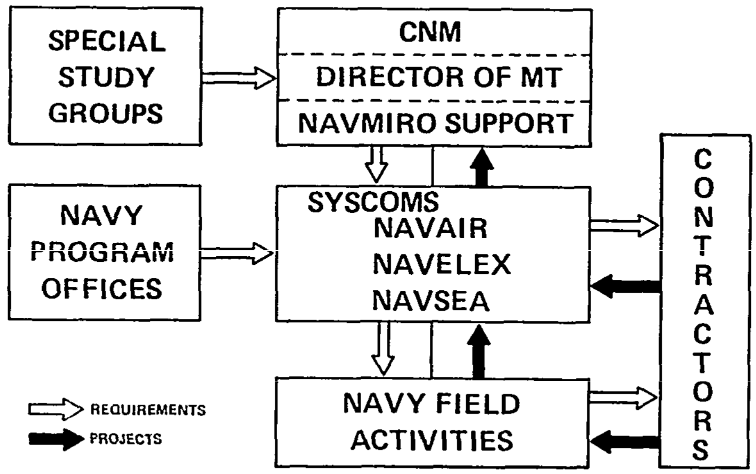
FOR THOSE OF YOU WHO ARE N0t FAMILIAR WITH OUR PROGRAM, MANUFACTURING TECHNOLOGY IS A MULTIDISCIPLINED EFFORT WHICH PROVIDES "SEED MONEY" TO ACCELERATE THE TRANSITION OF EMERGING TECHNOLOGY T0 INDUSTRIAL CAPABILITY. THESE OBJECTIVES CENTER ON THE REDUCTION OF MATERIAL ACQUISITION COSTS TO SUPPORT CURRENT AND ANTICIPATED NEEDS OF THE FLEET, OUR AIM IS TO INCREASE PRODUCTIVITY, AND DECREASE LEAD TIMES, BY APPLYING NEW TECHNOLOGY IN THE MANUFACTURING ARENA,

To ACCOMPLISH THIS, THE NAVY APPLIES A LEAN, BUT HIGHLY FUNCTIONAL, ORGANIZATION, MANAGEMENT OF THE PROGRAM Is CENTERED IN THE OFFICE OF THE DIRECTOR, UNDER THE CHIEF OF NAVAL MATERIAL, EACH HARDWARE SYSTEM COMMAND (NAVAIR, ELEX AND SEA) SET UP AN OFFICE TO EXECUTE THE PROGRAM, MOST OF THE INDIVIDUAL PROJECTS ARE MANAGED THROUGH ENGINEERS OR TECHNICAL EXPERTS AT FIELD ACTIVITIES, NAVMIRO, A NAVMAT EXTENSION AT THE NAVY YARD IN PHILADELPHIA, PROVIDES TECHNICAL SUPPORT TO THE PROGRAM DIRECTOR,

IN A SIGNIGICANT, RECENT DEVELOPMENT, THE OFFICE 0F THE AssIsTANT SECRETARY OF THE NAVY (MRA&L) HAS ESTABLISHED A “PRINCIPAL FOR PRODUCTIVITY" (DR, JAMES TWEEDDALE), THE MT PROGRAM OFFICE WORKS IN CLOSE COORDINATION WITH THIS OFFICE, THIS WILL ENABLE MT PLANNING TO DIRECTLY INTERACT WITH THE SETTING OF POLICY ON A BROAD SPECTRUM OF NAVY ACQUISITION ISSUES, THIS ALLIANCE WILL ALSO SERVE TO HEIGHTEN VISIBILITY OF MT EFFORTS WITHIN THE NAVY AND TO EVOKE AN EMPHASIS ON PROGRAMS WHERE PIVOTAL PRODUCTIVITY ISSUES EXIST,

MT PROGRAM

REQUIREMENTS AND PROJECT PROGRESSION



PROJECT REQUIREMENTS

- DEPARTMENT OF THE NAVY REQUIREMENT
- M.T. PROBLEM SOLUTION
- ADEQUATE STATE-OF-THE-ART
- NO DUPLICATION OF EFFORT
- BEYOND NORMAL RISK OF INDUSTRY
- PROCESS ORIENTED

THIS SHOWS HOW THE ORGANIZATIONAL ELEMENTS INTERACT, TOGETHER WITH CONTRACTORS, TO GENERATE PROJECTS IN RESPONSE TO NAVY NEEDS.

IN ADDITION TO PROGRAM OFFICES AND SPECIAL STUDY GROUPS, CONTRACTORS PARTICIPATE IN A SIGNIFICANT WAY.

CONFIRMED REQUIREMENTS ARE PASSED FROM NAVMAT To THE SYSCOMS FOR FULL VERIFICATION AND SUBSTANTATION. PERFORMING ACTIVITIES DEFINE PROJECTS WHICH ANSWER THOSE REQUIREMENTS.

EACH PROJECT MUST MEET CERTAIN CRITERIA IN ORDER TO BE CONSIDERED FOR FUNDING UNDER THE MT PROGRAM.

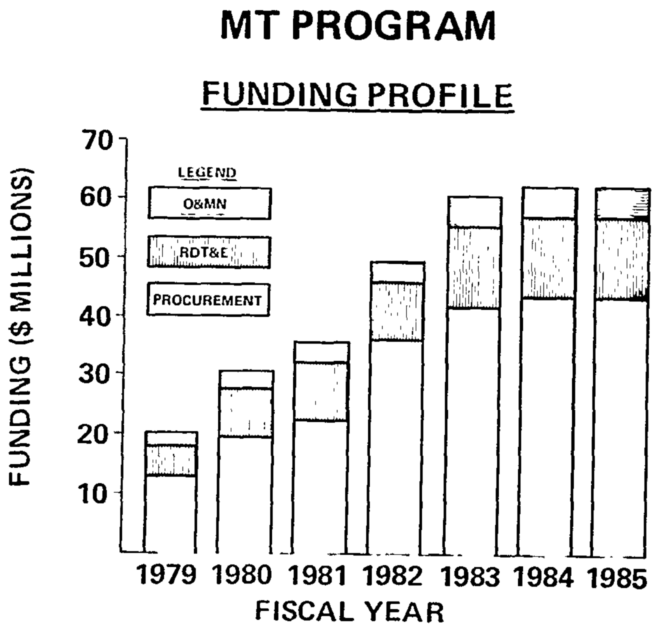
IT MUST SATISFY A CURRENT OR ANTICIPATED NAVY REQUIREMENT

IT MUST OFFER A SOLUTION TO A MANUFACTURING PROBLEM

IT SHOULD DEMONSTRATE ADEQUATE STATE-OF-THE-ART (THIS MEANS THAT THE TECHNOLOGY MUST HAVE ALREADY BEEN SHOWN FEASIBLE TO THE EXTENT THAT PROBABILITY OF SUCCESS IS HIGH)

IT MUST BE BEYOND THE NORMAL RISK OF INDUSTRY IF ANY QUALIFIED SEGMENT OF INDUSTRY WILL COMMIT PRIVATE CAPITAL - WE SHY FROM ACTIVE SUPPORT)

THE PROJECT MUST BE PROCESS ORIENTED WE DO NOT PROVIDE A DESIGN CHANGE FUNCTION, BUT WE DO LOOK FOR GENERIC APPLICATIONS IN PROCESS DEVELOPMENT (WE CONSIDER HARDWARE ITEMS PRODUCED TO BE SIMPLY VEHICLES FOR PROCESS DEMONSTRATION



FY79 HIGHLIGHTS

- PROJECTS PROCESSED 109
  - NEW STARTS 37
  - COMPLETED 14
  - ON-GOING 58
- PROJECTS IMPLEMENTED
- COMPLETED FOUR STUDIES
- INITIATED INVESTMENT STRATEGY PLAN

THE FUNDING IN SUPPORT OF OUR PROGRAM, LOOKS LIKE THIS: THE FY80 PROGRAM IS BUDGETED FOR $30,6 MILLION WHICH IS SOMEWHAT BELOW OUR PREDICTION OF LAST YEAR, HOWEVER, IN COMPARISON WITH FY79, IT REPRESENTS A 50% INCREASE, THIS, TOGETHER WITH PROJECTED FUNDING LEVELS, INDICATES THE NAVY'S EXPANDING INTEREST IN THE PROGRAM, THE PROJECTED FUNDING LEVEL FOR FY81 IS OVER $30 MILLION, ALSO, ADM, WHITTLE, THE CNM, RECENTLY INITIATED A MAJOR NAVY EFFORT IN SUPPORT OF ALL PRODUCTIVITY INTERESTS, THIS WILL BE ACCOMPANIED BY A SUBSTANTIAL FINANCIAL COMMITTMENT, BEGINING IN FY82, AND IT WILL INCLUDE ELEMENTS OF THE MT PROGRAM.

TURNING TO HIGHLIGHTS OF FY79, THIS SHOWS SOME KEY POINTS, I'D LIKE TO PUT THINGS IN PROPER PERSPECTIVE, HOWEVER, FY79 IS ONLY THE THIRD YEAR OF EXISTENCE FOR A FUNDED NAVY PROGRAM, ACCORDINGLY, MOST OF THE FY77 PROJECTS ARE JUST NOW COMING TO FRUITION, THIS IS REFLECTED IN THE PERCENTAGE OF IMPLEMENTED TO COMPLETED PROJECTS, WE EXPECT THIS TO PICK-UP SIGNIFICANTLY, WE COMPLETED FOUR INVESTMENT OPPORTUNITY STUDIES THIS YEAR, (I'LL SAY MORE ABOUT THESE LATER) AND WE INITIATED AN ANALYSIS OF THESE STUDIES IN ORDER TO FORM AN INVESTMENT STRATEGY PLAN, THIS PLAN WILL EMPHASIZE THE COMMANDS RECOGNITION OF COST INTENSIVE MANUFACTURING STEPS AND KNOWN PROCUREMENT NEEDS WHILE MAXIMIZING THE SAVINGS BENEFITS, WE FEEL THAT THIS IS NECESSARY,. IN ORDER TO MAXIMIZE THE IMPACT FROM OUR LIMITED RESOURCES,

NAVY MANUFACTURING TECHNOLOGY PROGRAM

MANUFACTURING TECHNOLOGY INVESTMENT OPPORTUNITY STUDIES

- ELECTRONICS
- WEAPONS
- SHIPBUILDING
- SHIPS OVERHAUL
- AIRCRAFT MANUFACTURE
- AIRCRAFT OVERHAUL

IN 1976, THE NAVY MADE AN AGREEMENT WITH THE SECRETARY OF DEFENSE TO CONCUCT COST DRIVER STUDIES IN THESE AREAS. Two OF THESE STUDIES, ELECTRONICS AND SHIPS CONSTRUCTION WERE COMPLETED LAST YEAR. I'LL COMMENT ON THE SHIPBUILDING STUDY AND THE RECENTLY COMPLETED SHIPS OVERHAUL STUDY.

GENERALLY, THE SHIPBUILDING STUDY RE-EMPHASIZED THE NATURE OF THE INDUSTRY AS BEING BASICIALLY A LABOR INTENSIVE AND FIXED POINT CONSTRUCTION PROCESS, THIS SUMMARY PROVIDES A MORE DETAILED VIEW OF THE FUNCTIONAL MANPOWER COSTS, AND THE DATA POINT TO THE NEED FOR THESE CHANGES

MORE AUTOMATION TO REDUCE LABOR CONTENT AND DEPENDANCY ON HIGH SKILLS

STREAMLING OF PLANNING, SCHEDULING AND CONTROL OPERATIONS

EMPHASIS ON PORTABLE TOOLS WHICH TAKE TECHNOLOLGY AND AUTOMATION ABOARD THE SHIP

ALL TOLD, THIS STUDY HAS PROVIDED A GOOD FOUNDATION FOR PLANNING OUR MT EFFORTS IN SHIPBUILDING.

SUMMARY OF COST FACTORS IN SHIP CONSTRUCTION

NOMINAL FUNCTIONAL WORK GROUP	PERCENT DISTRIBUTION OF MANHOURS BY SHIP CLASS							
	DD 963	SSN 688	FFG 7	CVN 68	CGN 38	LHA 1	AD 41	AS 39
ELECTRICAL	22	9	13	8	10	16	7	7
PIPEFITTING	13	15	9	9	11	15	12	12
WELDING	10	17	7	15.5	14	12	23	23
SHIPFITTING	13	10	10	11	8	13	12	12
QUALITY ASSURANCE	7	10	4	6	8	-6	1	1
OUTSIDE MACHINIST	5	8	4	6	7	4	5	5
SHEETMETAL	6	4	3	3	3	6	9	9
PAINTING & BLASTING	7	2	5	4	2	9	4	4
JOINER	6	1		2	2	8	1	1
RIGGING & CRANE OPERATIONS	3	2	1	6	5	3	4	4
SHIPWRIGHT	2	1	3	1	1	2	1	1
MACHINE SHOP	1	2	2	1.5	1	<I	2	2
DRAFTING		8	IO	15	16			
PLANNING & ESTIMATING			10				4	4
TECHNICAL		1	5	5	5			
MOLD LOFT	`.1	1	4	1	1	<l	1	1
PROJECTS SUPPORT	1		3			<l	4	4
TRANSPORTATION-MATERIAL HANDLING		1	2	<1	<I		1	1
HELPERS & CLEANING	2	3		1	1	3	3	3
CHIPPING & GRINDING	2	2	2	2	2	2	2	2
SECURITY		3	1	1	1		1	1
MISCELLANEOUS	1	3	2	2	2	1	3	3

NAVY MANUFACTURING TECHNOLOGY PROGRAM

SHIPBUILDING HIGH COST AREAS

- HULL CONSTRUCTION
- ELECTRICAL AND ELECTRONICS
- PIPEFITTING
- OUTSIDE MACHINIST
- SHEETMETAL

SHIPBUILDING TECHNOLOGY IMPROVEMENTS

- AUTOMATION OF PROCESSING
  - REDUCE LABOR CONTENT AND SKILLS LEVELS
- STREAMLINE MANUFACTURING PLANNING
  - ORDERING
  - HANDLING
  - SCHEDULING
  - INVENTORY CONTROL
- PORTABLE TOOLING
  - SHIPBOARD UTILITY
  - UNIQUE CAPABILITIES

MT PROGRAM

POTENTIAL PAYOFFS IN SHIPS OVERHAUL FUNCTIONS

MAJOR REPAIR OPERATIONS	REDUCTION IN DIRECT LABOR COSTS ($M)	REDUCED TIME IN OVERHAUL DAYS	($M)
PIPING & VALVES	9.0	853	280
BOILER	1.8	1,530	215
ELECTRICAL	10.8	-	-
STRUCTURAL	3.0	-	
WELDING	14.0	-	-
CLEANING & PAINTING	6.0	66	11

THE SHIPS OVERHAUL STUDY IDENTIFIED THE MORE PROMINENT LABOR REQUIREMENTS AND COSTS IN OVERHAUL AS PERFORMED IN NAVY YARDS, PIPING, BOILER AND ELECTRICAL REPAIRS WERE AMONG THE LEADING COST CONTRIBUTORS, ALTHOUGH WELDING, STRUCTURAL REPAIRS AND CLEANING AND PAINTING WERE ALSO EXAMINED. PLANNING, BUDGETING AND CONTROL OF WORK FLOW WITHIN THE YARDS WERE, AGAIN, SINGLED OUT AS AREAS WHERE SIGNIFICANT IMPROVEMENTS COULD BE MADE, AND TIME SAVINGS WERE CALCULATED IN TERMS OF FLEET READINESS FACTORS BASED ON "ACHIEVABLE" REDUCED TIME IN THE YARDS. A SUMMARY SHEET ON SUCH AN ANALYSIS IS SHOWN.

FACTORS EFFECTING OVERHAUL COSTS AND DURATIONS

' BUDGETS ASSUME INCREASING COSTS

' EXHAUSTING BUDGET TENDANCY

' WORKLOAD/STAFFING LEVELS

' "TRADITIONAL" WORK RULES

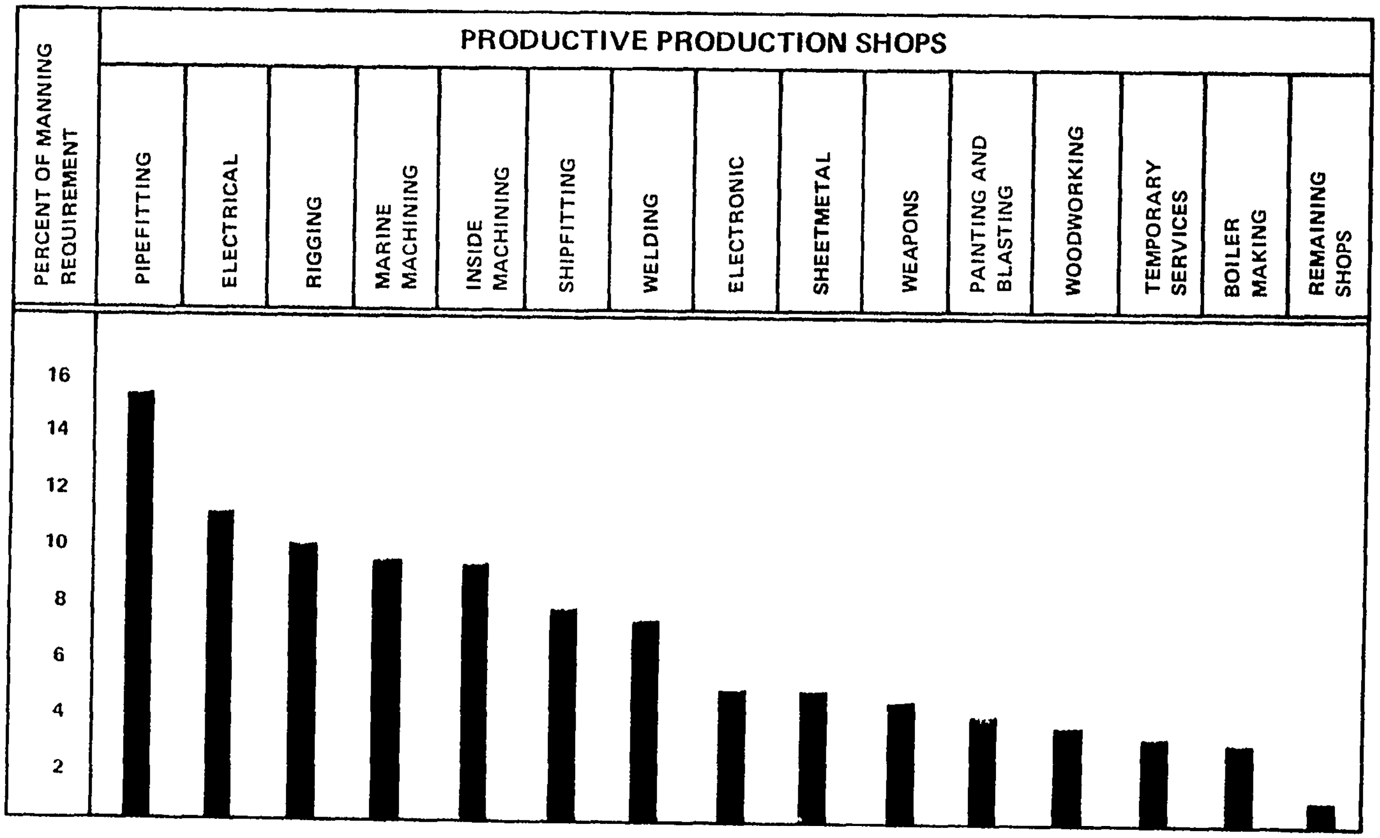
' PLANNING PROCESS ENCOURAGES HIGH LEVEL OF PREVENTIVE MAINTENANCE

' NON-STANDARDIZATION IN DESIGN AND PROCUREMENT

' PROCUREMENT LEAD TIME DELAYS

' CREW MAINTENANCE PRACTICES

SHIP OVERHAUL COST DRIVERS



AGAIN, THE EFFECTIVENESS OF BETTER PORTABLE TOOLING WAS IDENTIFIED IN THE YARD OVERHAUL ENVIRONMENT.

SOME OTHER FACTORS, THAT WERE FOUND TO SIGNIFICANTLY INFLUENCE OVERHAUL TIME AND DOLLAR COST, ARE SUMMARIZED HERE.

TECHNOLOGY TRANSFER WAS JUST DISCUSSED (IN AN EARLIER PAPER) FROM THE SHIPBUILDING STANDPOINT, THE NAVY MT PROGRAM PARTICIPATES IN A SORT-OF TRI - SERVICE/INDUSTRY CONSORTIUM, THROUGH MTAG, THE MANUFACTURING TECHNOLOGY ADVISORY GROUP, THIS GROUP HAS SIX TECHNICAL SUBCOMMITTEES WHICH ACTIVELY WORK WITH INDUSTRIAL SOCIETY COUNTERPARTS TO FOCUS ON TECHNICAL EXCHANGE, THIS IS DONE ON A CONTINUING BASIS THROUGH BOTH FORMAL AND INFORMAL MEANS, THE SUBCOMMITTEES ALSO REVIEW EACH OF THE SERVICES PROGRAMS TO:

IDENTIFY AREAS OF COMMON INTEREST

COORDINATE SERVICE EFFORTS &

ELIMINATE DUPLICATION

THE SUBCOMMITTEES CONDUCT MT WORKSHOPS IN HIGH INTEREST AREAS, THESE ARE A FEW HELD WITHIN RECENT MONTHS, THEY HAVE BEEN CHARACTERIZED BY ACTIVE INDUSTRY PARTICIPATION FOLLOWED BY DOD PLANNING SESSIONS,

TECHNOLOGY TRANSFER THROUGH MTAG

TECHNICAL SUBCOMMITTEES

- COMPUTER AIDED DESIGN/MANUFACTURE
- ELECTRONICS & OPTICS
- METALS
- NON-METALS
- INSPECTION & TESTING
- AMMUNITION

MTAG WORKSHOPS

TECHNOLOGY INTEREST AREAS

- LASER MANUFACTURING
- CASTING TECHNOLOGY
- JOINING TECHNOLOGY
- TRAVELING WAVE TUBE MANUFACTURING
- HYBRID CIRCUIT PROCESSING
- COMPONENTS & PACKAGING TECHNOLOGY
- COMPOSITES MANUFACTURING

TECHNOLOGY TRANSFER

- END-OF-CONTRACT DEMONSTRATIONS
- MTAG SUBCOMMITTEE INTERACTION
- MTAG SUBCOMMITTEE WORKSHOPS

END-OF-CONTRACT BRIEFINGS AND PROCESS DEMONSTRATIONS ARE ALSO USED TO DIFFUSE TECHNOLOGY, WITHIN THE DEFENSE PRODUCTION SECTOR OF THE INDSUTRY, CONTRACTORS ARE REQUIRED TO BRIEF THEIR INDUSTRY ON THEIR ACCOMPLISHMENTS, GENERALLY DISCUSSED ARE THE PROS AND CONS OF THE PROCESSING AND THE VOIDS REMAINING IN THE TECHNOLOGY, THE NAVY WOULD LIKE TO BECOME MORE ACTIVE IN COMMUNICATING WITH THE SHIPBUILDING INDUSTRY IN ALL THESE MODES OF TECHNOLOGY TRANSFER,

TYPICAL MANUFACTURING TECHNOLOGY PROJECTS

- ION IMPLANTATION PROCESS
- ISOTHERMAL SHAPE ROLLING
- LOW COST TORPEDO PROPELLERS
- ULTRAFINE CARBON-CARBON WEAVING
- FOAM FILLED FIBERGLASS RADOMES
- N/C ULTRASONIC DRILLING OF CERAMICS

JUST TO ILLUSTRATE THE DIVERSITY AND SCOPE OF THE NAVY MT PROGRAM INVOLVMENT, SOME TYPICAL PROJECTS ARE LISTED HERE:

ESTABLISHMENT 0F ION IMPLANTATION, AS A PROCESS FOR MANUFACTURING DELICATE ELECTRONIC CIRCUITS FOR MEMORY AND DEVICE APPLICATIONS.

ESTABLISHMENT OF ISOTHERMAL SHAPE ROLLIING FOR NET SHAPE PROCESSING OF TITANIUM AND SUPERALLOY FOR ENGINE & AIRFRAME STRUCTURES TO MINIMIZE CRITICAL MATERIALS USAGE AND ROUGH MACHINING COSTS.

- W COST TORPEDO PROPELLERS WILL REPLACE MACHINED ALUMINUM PROPRLLERS WITH INJECTION MOLDED, FIBERGLASS REINFORCED POLYESTER PROPELLERS, AN APPROXIMATE $1 MILLION COST AVOIDANCE IS ENVISAGED BY 1987.

- ULTRA FINE CARBON-CARBON WEAVING WILL BE USED TO FABRICATE MULTIDIRECTIONAL, CARBON-CARBON REINFORCED, REENTRY VEHICLE, NOSE TIP PREFORMS AND REDUCE COSTS BY $14,000 A UNIT.

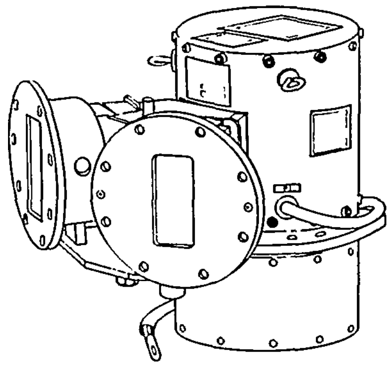
- FOAM FILLED FIBERGLASS RADOMES PRODUCTION COSTS WERE REDUCED FROM $6000 TO $450 PER UNIT USING NEW PROCESSING TECHNIQUES. A TOTAL COST AVOIDANCE OF $4 MILLION IS EXPECTED.

- NUMERICALLY CONTROLLED ULTRASONIC DRILLING AND POLISHING OF CERAMICS FOR LASER GYROS WILL REDUCE PRODUCTION COSTS BY $2750 A UNIT.

NEXT I'LL DISCUSS SOME OTHER NAVY PROJECTS WHICH HAVE HELD, OR ARE ABOUT TO HOLD, END-OF-PROJECT DEMONSTRATIONS.

M T P R O G R A M

SFD-261 CROSSED-FIELD AMPLIFIER (CFA)



INVESTMENT: $265,000

SAVINGS: $900,000 PER SHIP

FY 80 OUTLOOK

- PROJECTS EXPECTED TO BE PROCESSED 112
  - EXPECTED NEW STARTS 53
  - EXPECTED COMPLETIONS 38
  - EXPECTED TO BE ON-GOING 21
- IMPLEMENT INVESTMENT STRATEGY PLAN
- INITIATE TRACKING SYSTEM

A PROJECT, WHICH MAY BE FAMILIAR TO MANY OF YOU, IS THE THE COMPUTERIZED BENDING OF FRAMES FOR SHIP STRUCTURES. THIS PROJECT, CURRENTLY UNDERWAY IN .CQNJUNCTION WITH NASSCO WILL DEMONSTRATE INDUSTRIAL CAPABILITY TO BEND UP TO 23 INCH "I" BEAMS WITH 10 INCH FLANGES USING A FOUR POINT BEAM BENDER WITH COMPUTER CONTROL. THIS WILL REPLACE MANUAL TEMPLATING AND THREE POINT BENDING METHODS, AND IT WILL PROVIDE BENDS THAT PRECLUDE TWISTS AND DISTORTIONS AND ARE PRECOMPENSATED FOR SPRINGBACK AND OTHER MATERIAL CHARACTERISTICS. (YOU MAY HEAR MORE ABOUT THIS IN ONE OF THE SPECIALITY SESSIONS THIS AFTERNOON).

IN ANOTHER PROJECT, ACOUSTIC WELD MONITORING USES TRANSDUCERS TO MONITOR WELDS FOR CRACKS AND IMPERFECTIONS. A COMPUTERIZED RECORDING DEVICE LOCATES CRACKED WELDS TO ENABLE EARLY REPAIR WITHOUT WAITING DAYS OF “CURING PERIOD” FOR X-RAY INSPECTION.

IN A THIRD PROJECT, CHANGES IN THE PROCESSING OF THE CROSSED FIELD AMPLIFIER FOR THE AEGIS (SPY-l) RADAR HAS REDUCED THE COST FROM $21,000 TO $12,000 EACH. THIS TRANSLATES INTO A SAVINGS OF ABOUT $900,000 PER SHIP SET.

TURNING TO FY30 AND BEYOND, WITH OVER 30 MILLION DOLLARS WE EXPECT 53 NEW STARTS IN THE FY80 PROGRAM. SOME OF THESE WILL BE THE DIRECT RESULT OF THE COST DRIVER STUDY IDENTIFIED PROBLEMS.

ALSO DURING THIS TIMEFRAME, IMPLEMENTATION OF AN INVESTMENT STRATEGY PLAN AND PROJECT RANKING SYSTEM IS ANTICIPATED. THE FULL IMPACT OF THESE TWO ACTIONS WILL NOT BE EVIDENT UNTIL FY81 AND FOLLOW-ON YEARS, HOWEVER.

FY80 WILL PROVIDE MUCH ADDITIONAL SAVINGS DATA FROM IMPLEMENTED PROJECTS; THOSE BEGUN IN FY77. THESE DATA WILL BE FACTORED INTO THE DATA BASE FOR TRACKING THE RETURN ON INVESTMENT MADE BY THE NAVY IN RECENT YEARS. WE ARE LOOKING FORWARD WITH ANTICIPATION TOWARD ATTRACTIVE RESULTS, WHICH WE FEEL WILL PROVIDE FURTHER IMPETUS TO OUR PROGRAM.

IN AN ATTEMPT TO SATISFY THE NEEDS OF THE FLEET, ENHANCE PRODUCTIVITY AND PRODUCE THE BEST PAYBACK, WE EXAMINED THE ACQUISITION OF WEAPON SYSTEMS IN THE OUT YEARS AND IDENTIFIED SEVERAL MAJOR THRUST AREAS OF GENERIC INTEREST TO THE NAVY PROGRAM, SOME SPECIFIC AREAS ARE SHOWN HERE. THIS LISTING IS NOT INTENDED TO REFLECT AN ORDER OF PRIORITY NOR SHOULD IT BE CQNSIDERED COMPLETE. THE IDENTIFIED THRUSTS ARE VIEWED AS BUILDING BLOCKS IN OUR PROGRAM, AND THEY ARE PRESENTED HERE TO GIVE THE PRIVATE SECTOR LEAD TIME IN RESPONDING TO THESE INTERESTS AND FOR STRUCTURING THEIR PLANS ACCORDINGLY.

NAVY "MANAGEMENT HAS MADE A DECISION TO MOUNT A MAJOR INITIATIVE TO INCREASE IN-HOUSE PRODUCTIVITY, STARTING IN FY82, MT PROJECTS WILL BE ALIGNED WITH THIS INITIATIVE.

IT IS ANTICIPATED THAT PROPOSALS GENERATED AS A DIRECT RESULT OF THE AIRCRAFT AND SHIPS OVERHAUL STUDIES WILL PROVIDE A MAJOR CONTRIBUTION TO THIS INITIATIVE.

MT PROGRAM

MANUFACTURING/OVERHAUL RELATED THRUSTS/INTERESTS

- NEAR NET SHAPE
- VHSIC
- HIGH POWER LASERS
- COMPUTER AIDED MANUFACTURING
- MICRO ELECTRONICS
- COMPOSITE MATERIALS
- ROBOTICS
- ELECTRO-OPTICS

SUMMARY

- NAVY/INDUSTRY COOPERATION
- APPLY VARIETY OF TALENTS
- CONSTRICTING PROCUREMENT CHALLENGE
- COORDINATE CAPABILITY WITH GENERIC NEEDS
- FAVORABLE ENVIRONMENT FOR IMPROVED PRODUCTIVITY

IN SUMMARY I WOULD LIKE TO

EMPHASIZE THESE POINTS:

THE NAVY MANUFACTURING TECHNOLOGY PROGRAM RELIES ON A VARIETY OF TECHNOLOGIES AND EXPERTICE FROM THROUGHOUT THE DEFENSE INDUSTRIAL COMMUNITY.

OVER THE COMING MONTHS, THE COMBINED BODY OF IN-HOUSE AND PRIVATE INDUSTRIAL TALENT WILL BE STRESSED TO MORE CLOSELY ADDRESS COST IDENTIFIED MANUFACTURING NEEDS WHILE OBSERVING THE REALITIES OF A CONSTRICTING PROCUREMENT ARENA.

THIS SHOULD INCLUDE ATTENTION TO GENERIC THRUSTS, OF INTEREST TO THE COMMANDS, COUPLED WITH A RECOGNITION OF KNOWN PROCUREMENT AND MANUFACTURING NEEDS. THIS WILL HELP FORM A MORE COHESIVE PROGRAM WHILE RETAINING CURRENT PROGRAM ADVANTAGES.

TO DO THIS WE WILL EMPLOY THE ANALYTICAL RESULTS OF STUDY DERIVED COST DRIVER DATA, TOGETHER WITH THE SUGGESTIONS AND TECHNOLOGICAL SOLUTIONS PROVIDED IN ANSWER TO OUR IDENTIFIED GOALS.

WE FEEL THAT THE OUTLOOK IS GOOD AND THAT OUR EXPERIENCE IN THE PAST HAS BEEN WORTHWHILE. WE LOOK FORWARD TO IMPROVING OUR RECORD AND OUR PERFORMANCE - WITH YOUR HELP.

THE ROLE OF OPERATIONS RESEARCH IN SHIPBUILDING

James Low
Systems Analyst
National Steel and Shipbuilding Company
San Diego, California

Mr. Low is currently participating in the design and development of a computer-aided estimating system for shipbuilding under the auspices of REAPS.

Mr. Low is a graduate of the University of Strathclyde in Glasgow, Scotland, with a degree in operations research and economics. He has in-depth knowledge of the shipbuilding process, and 4 years experience in shipbuilding research with the British Ship Research Association including: operations research projects, productivity analyses, market studies, and simulations. He also has 7 years experience in data processing including: environmental monitoring systems, modeling of shipbuilding process, simulation, and project management systems.

Steve Knapp
Systems Analyst
National Steel and Shipbuilding Company
San Diego, California

Currently Mr. Knapp is engaged in designing a major computer system which will logically connect the major planning department systems by utilizing a new work definition technique, and incorporating this company's new planning philosophy.

Mr. Knapp has a degree in computer science from Pennsylvania State University, and has completed course work toward a masters degree in computer science at San Diego State University. He has 10 years experience in numerous facets of the data processing environment, including: military NTDS systems, simulation, operations research, advanced aerospace systems, general accounting, and shipbuilding production control, project management systems, and labor tracking systems.

Recent evaluations of the shipbulding industry indicate that a substantial reduction of potential revenues, both by industry and individual shipyards, will occur during the next decade. Foreign competition, limited military procurements, a tightening of the commercial market, and the economy of the country in general are all affecting the order books of all U.S. shipyards.

Realizing that increased technology can be of use to improve these ship-bulding conditions, the authors prepared a short presentation for the recent REAPS Symposium which was held in San Diego in September, 1979. This paper describes the basic content of that presentation.

Operations Research in Shipbuilding

To evaluate the potential of Operations Research in the shipbuilding environment, we chose to demonstrate two applications of these techniques using an actual shipyard, which regrettably, is no longer in business. Investigation into recorded history presented us with an authentic case study, namely "Noah's Shipbuilding Company."

Noah had a small yard, incorporating a single ways, two shops, and miscella-neous support facilities. Recent negotiations with the Ultimate Customer gave Noah a veritable flood of orders, precipatated by very fluid market conditions.

Noah's yard had normally constructed only one type of ship, the Animal Retrieval Kraft (ARK). After subseqeunt redesign, coupled with an increased demand for larger capacities, he reorganized his facilities to build only

VLARKs, or Very Large ARK. To this end, the yard's construction services centered around this vessel with facilities and manpower necessary to support its construction.

Noah's latest contract, however, was for a ship capable of large capacities along with an increased loading/offloading capability. The ship, called the Tromp-on/Tromp-off (TO/TO), consisted basically of the original VLARK with a redesigned ramp system for high speed access by the animals.

This new ship caused Noah to re-evaluate his yard's potential because of the following reasons:

0 The TO/TO yielded a smaller profit margin over the VLARK.

0 Although the contract allowed for 40 rain days, the overall ship's construction schedule was tighter than Noah was accustomed to. For this contract, he literally had a drop-dead-date.

0 The ship's design called for an increased amount of venting than Noah's vent shop could' comfortably produce.

Understanding these constraints, Noah decided to employ Operations Research techniques to evaluate the problems of:

0 What product mix of VLARKs and TO/TOs would yield the best profit margin, and

0 What arrangements could be used to improve the productivity and output of his vent shop.

The O.R. techniques that he used will be discussed here. The product mix problem will be addressed by a Linear Programming, or L.P., model. The vent shop problem will be evaluated using Discrete Event Oriented Simulation techniques.

LINEAR PROGRAMMING PRODUCT MIX MODEL

By James Low

Linear Programming, or more commonly referred to as L.P., is a mathematical technique used in the allocation of scarce resources among competing demands in an optimal manner with respect to a predefined measure of effectiveness.

L.P. is most commonly used in product-mix situations to determine what quantities of which products should be produced to maximize profit, when many possible combinations and permutations exist. L.P. determines the best, or optimal, solution to the problem in a systematic and efficient manner.

In Noah's case, his products are competing for the limited facilities available, working against time constraints and also market limitations. The problem may be defined as follows:

0 The variables in the model are the number of ships of each type which will be constructed.

V = Number of VLARKs
T = Number of TO/TOs

These are referred to as the "Decision Variables."

0 The objective function which is to be optimized is defined as the profit resulting from ship construction.

VLARK profit = 1000 Shekels
TO/TO profit = 750 Shekels

The function is assumed to be linear and may be expresed as

PROFIT = 1OOOV + 750T

If the two ship-types utilized the same amounts of the same resources, it is obvious that Noah would build only VLARKs. But unfortunately, there are differing resource requirements and also a finite limit to the number of VLARKs which can be sold.

These resource requirements may be stated in the form of linear constraints on the model. The resource availabilities are also constraining factors. The labor force consists of two hundred people, evenly divided between ship and shop functions. In a year, the period in which Noah must make his killing, there are 313 "inside" working days, Sunday work being banned by decree. There are 273 "outside" working days due to a very reliable forecast of rain for 40 days and nights (never on Sundays). A VLARK requires 1500 man-days in the shop and 800 man-days on the ways. A TO/TO requires 900 man-days in the shop and 1200 man-days on the ways. In addition, there exists a finite demand for VLARKs, estimated by market analysis at 16 ships.

The linear constraints discussed can be expressed as follows:

0 Shop constraint

15OOV + 900T <= 31300

0 Ship constraint

800V + 1200T <= 27300

0 Market constraint

V<= 16

In addition to system constraints, certain assumptions must be made about the system.

0	"Certainty"	Noah was an accomplished prophet
0	"Linearity"	In the "objective function" and constraints
0	"Non-negativity"	Cannot build negative ships
0	"Additivity"	The whole = sum of the parts
0	Independence of Coefficients	
0	"Divisibility"	I.E. Continuous variables

Note that the last assumption is not realistic since we are dealing with integer variables, but it has been shown that the solution under the continuous assumption is sufficiently close in most situations to render integer programming techniques uneconomic.

The solution to the model can be obtained by a mathematical technique known as the "simplex method," or simply by graphing the feasible region. The feasible region is defined as the area bounded by the constraints and assumptions.

In order to depict the constraints graphically, we determine the intersection of any constraint line and the "V" and "T" axes. This gives us a straight line (we have assumed linearity) for that constraint. Referring to Figures LP1, LP2, and LP3, we note the straight-line ship, shop, and market constraints.

Overlaying the three constraint lines, we obtain *a* picture of the "feasible region," as shown in Figure LP3.

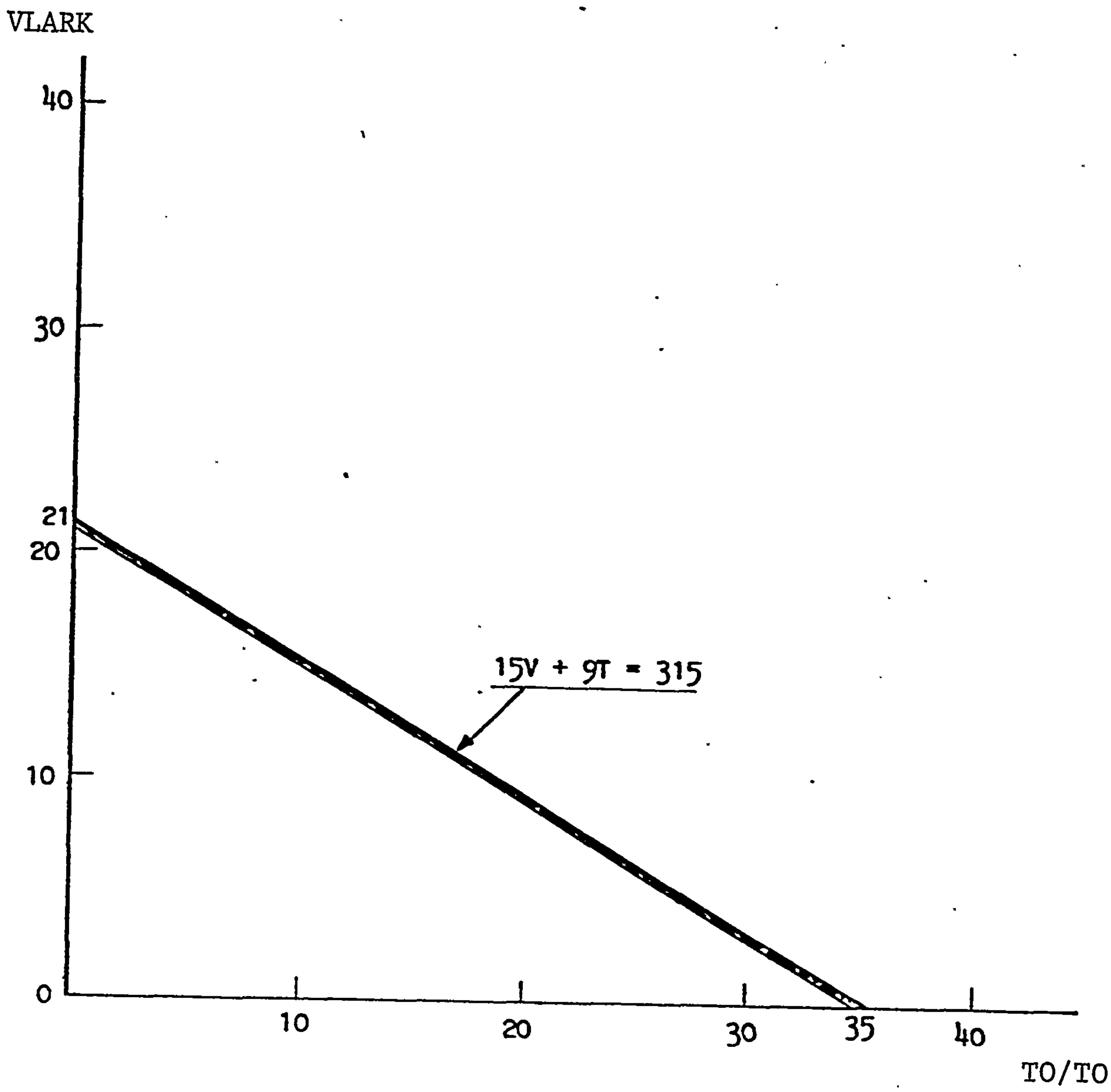


FIGURE LP1

SHIP CONSTRAINTS

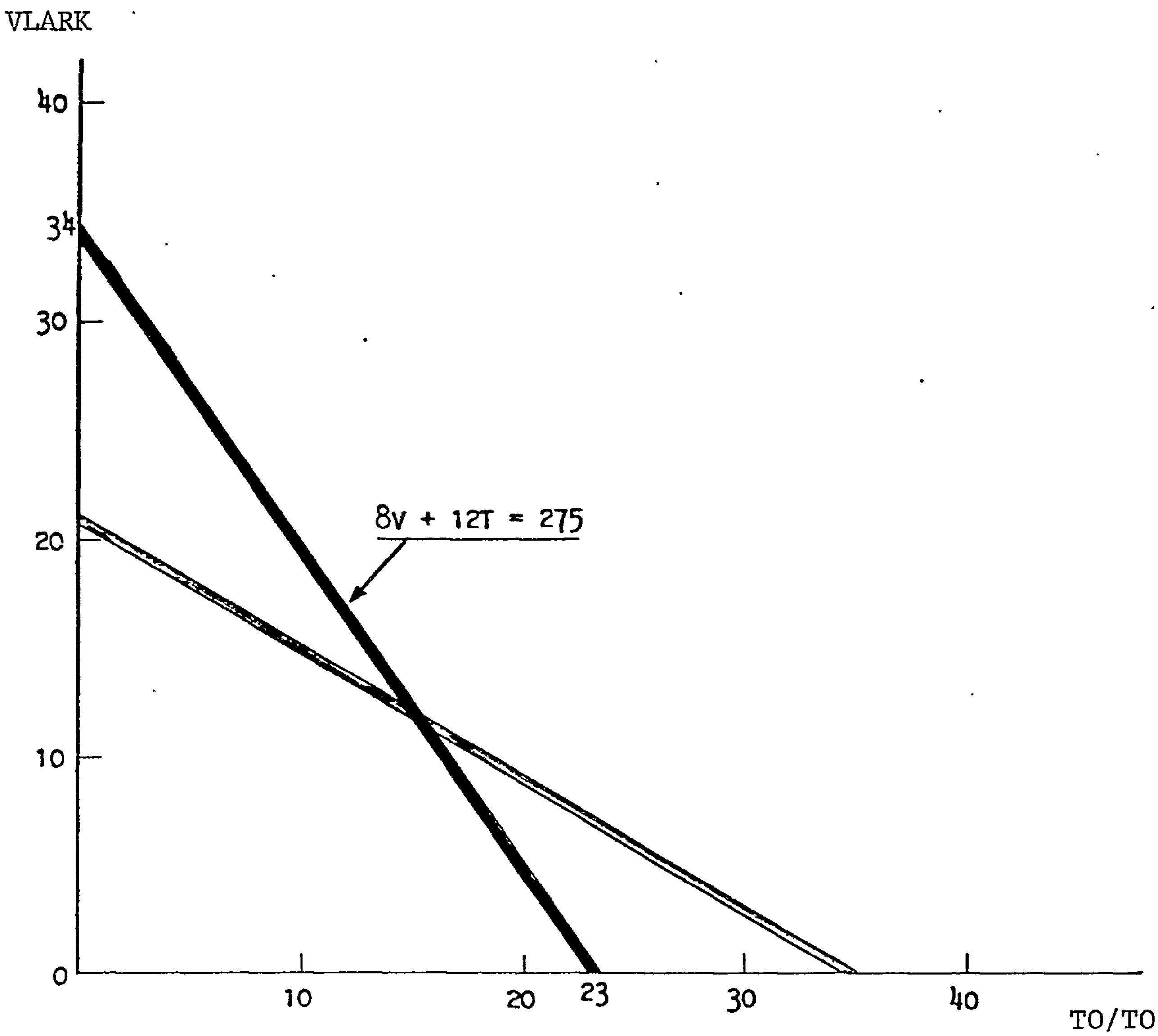


FIGURE LP2

ADD SHOP CONSTRAINTS TO SHIP CONSTRAINTS

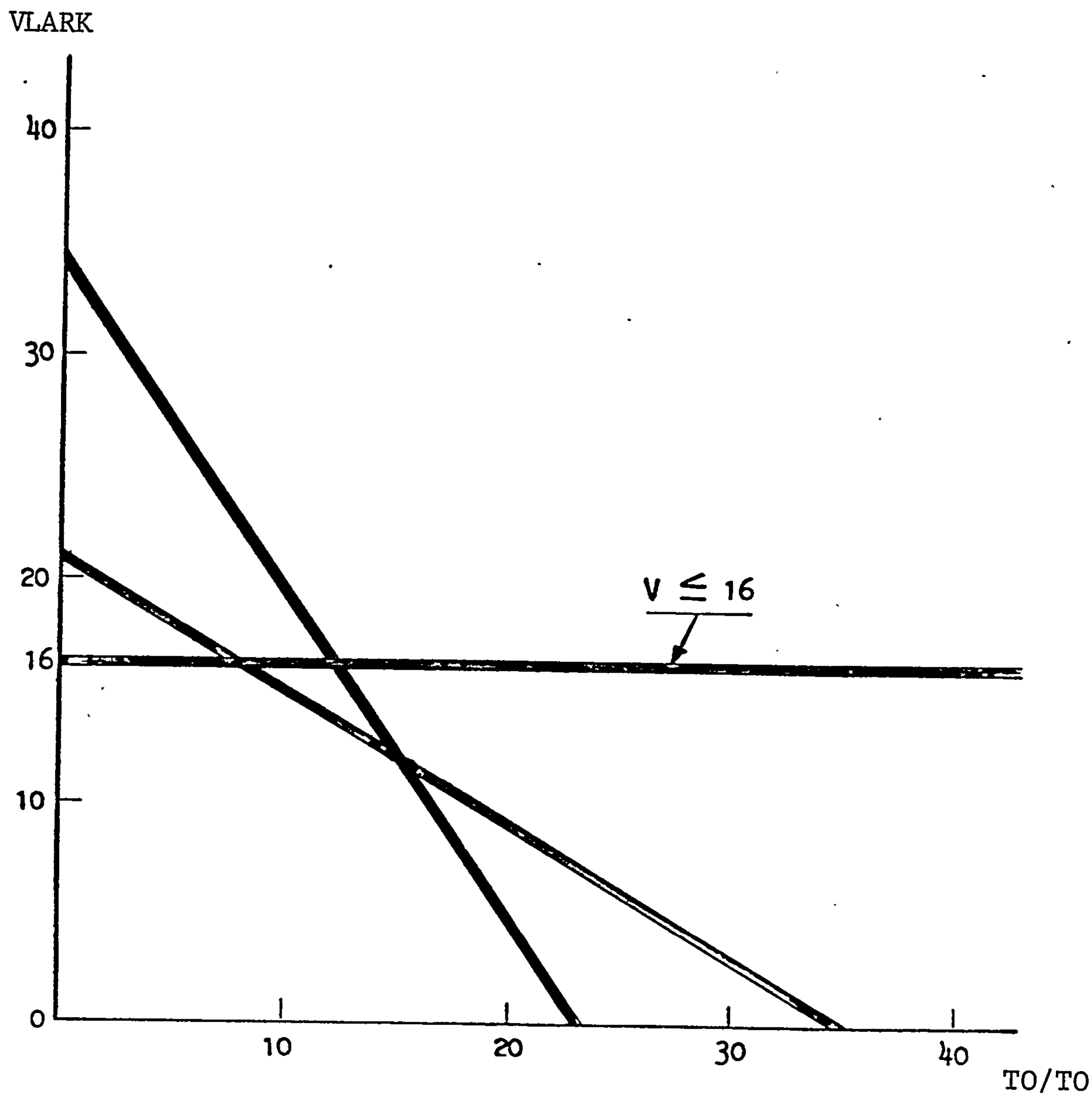


FIGURE LP3

MARKET CONSTRAINT OVER SHIP AND SHOP CONSTRAINTS

The profit is greatest along the boundary of the feasible region, and any optimal solution will lie on the boundary. The optimal solution may be obtained by enumeration of the intersections of the boundaries of the feasible region, or by the production of a graphical representation of the objective function. Refer to Figure LP4.

The objective function is graphed in the same way as the constraints. This function Line depicts the total profits which can be obtained by building entirely VLARKs or entirely TO/TOs. Note that, for any number of ships built, this objective function always represents the "best" profit picture possible, no matter how far that line is from the origin of the graph. This line is called the "isoprofit" line, and is drawn to cross the other constraint lines at the outermost point of the feasible region. As can be seen in Figure LP5, the coordinates of this coincident point represent the optimal solution.

From that point, we drop perpendicular Lines to both the "V" and "T" axes to determine how many VLARKs and TO/TOs should be built to best utilize Noah's resources, meanwhile realizing the maximum profits possible.

The example we have used is, of necessity, simplistic, and normal usage of Linear Programming requires sophisticated and powerful computer tools available as packages from sofware vendors. What we have attempted to do here is illustrate the principle of L.P. in such *a* manner that the concept of the methodology may be understood and the black art of Operations Research become less of an enigma.

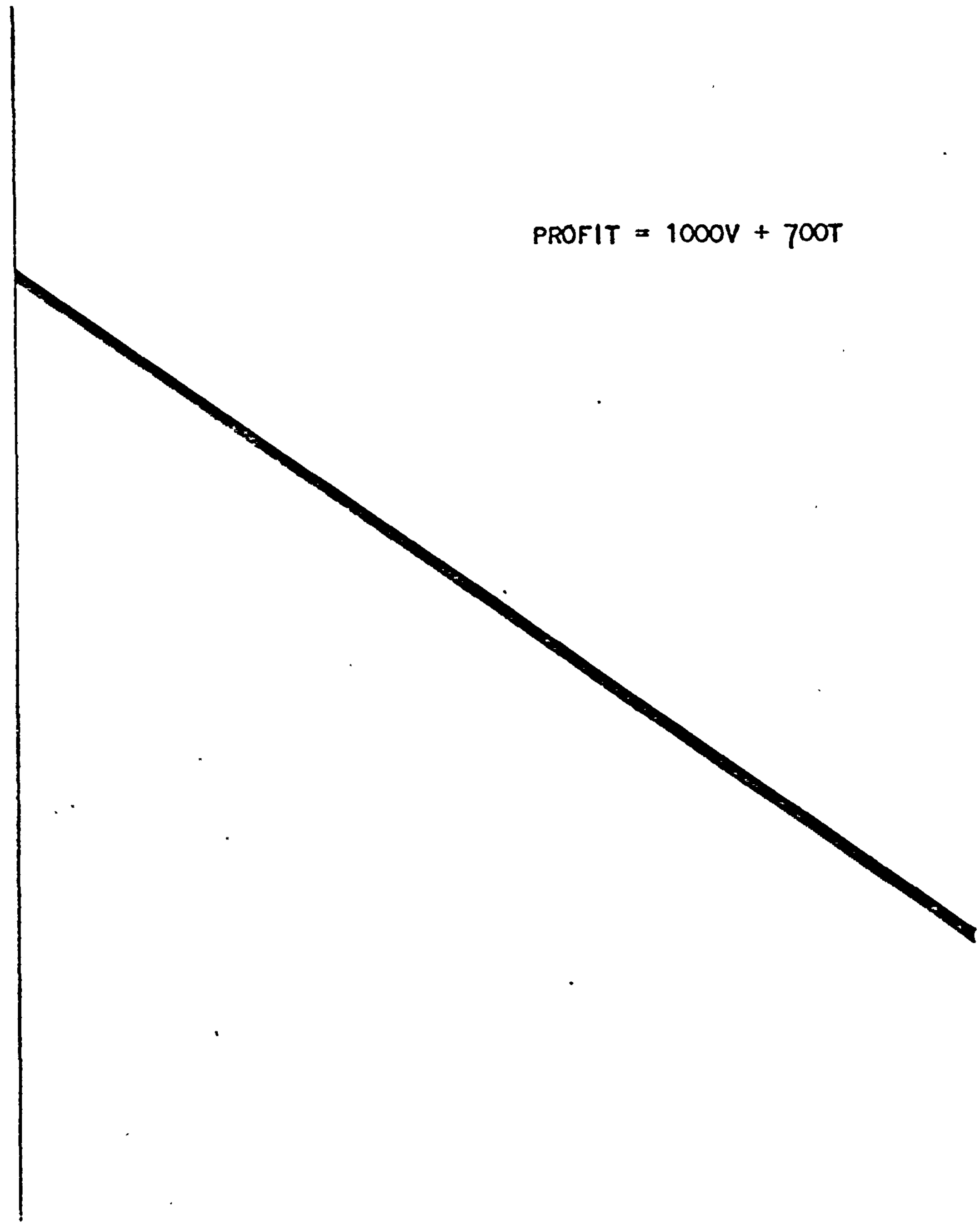


FIGURE LP4

"ISOPROFIT" LINE

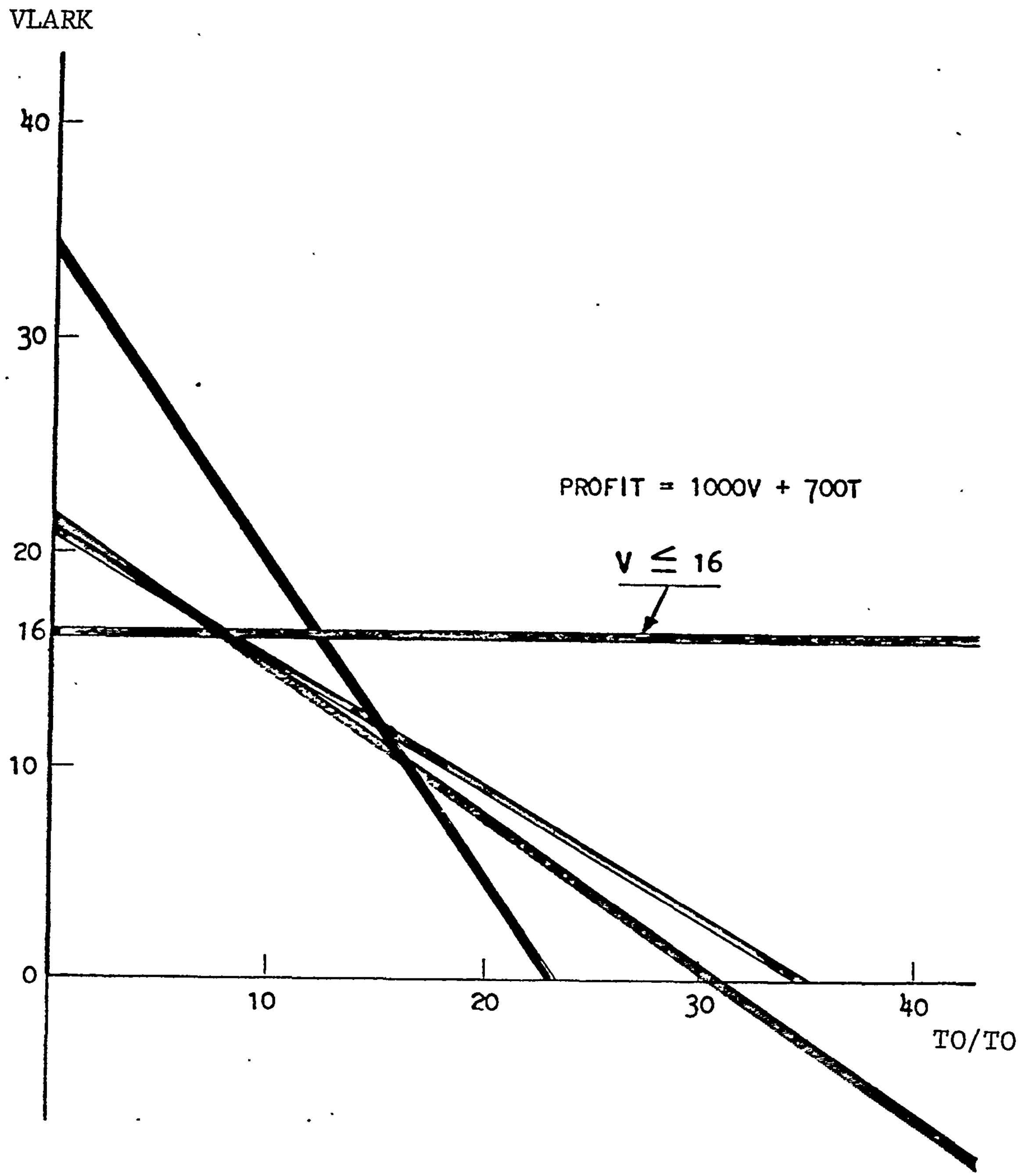


FIGURE LP5

ISOPROFIT LINE GRAPHED OVER CONSTRAINTS

DISCRETE SIMULATION OF THE VENT SHOP ENVIRONMENT

by Steve Knapp

As mentioned in the introduction, the TO/TO's design called for much more venting than Noah was accustomed to for the VLARK. The extreme vent requirements came from the fact that the high speed loading/off-loading caused the animals' metabolic rate to increase, resulting in a very unpleasant atmospheric condition within the hull.

Noah's primary concerns were as follows:

- To determine the maximum output capabilities of the vent shop as currently configured.
- To determine the required output to support the TO/TO's construction schedule.
- To ascertain the extent of facility enhancements needed to support the TO/TO. (Noah felt sure that his vent shop could not support the TO/TO).
- To analyze the material flow thru the vent shop in an attempt to improve material flow without expanding that shop's facilities.

Noah decided to approach these problems by employing a discrete, event oriented simulation model. Utilizing appropriate computer tools, most of which are off-the-shelf from mainframe vendors, Noah had his Operations Research staff create the necessary input entities to depict the vent shop as it currently existed. Material flow, machine set-up times, realistic labor consumption, standard management decisions, and machine utilization times *were* among the many items that the O.R. team measured, analyzed, and placed into the model.

To insure that the model would properly simulate the intended shop modifications, the Operations Research group chose to first set up the model to simulate the vent shop as currently configured. Not only would this validate the model against known thru-put, but would provide valuable insights necesary to modifying the model with regards to the proposed shop layout to support the TO/TO. Thus, by building the model *to* simulate the current shop facilities, material flow, available labor, and other known constraints, Noah was able to:

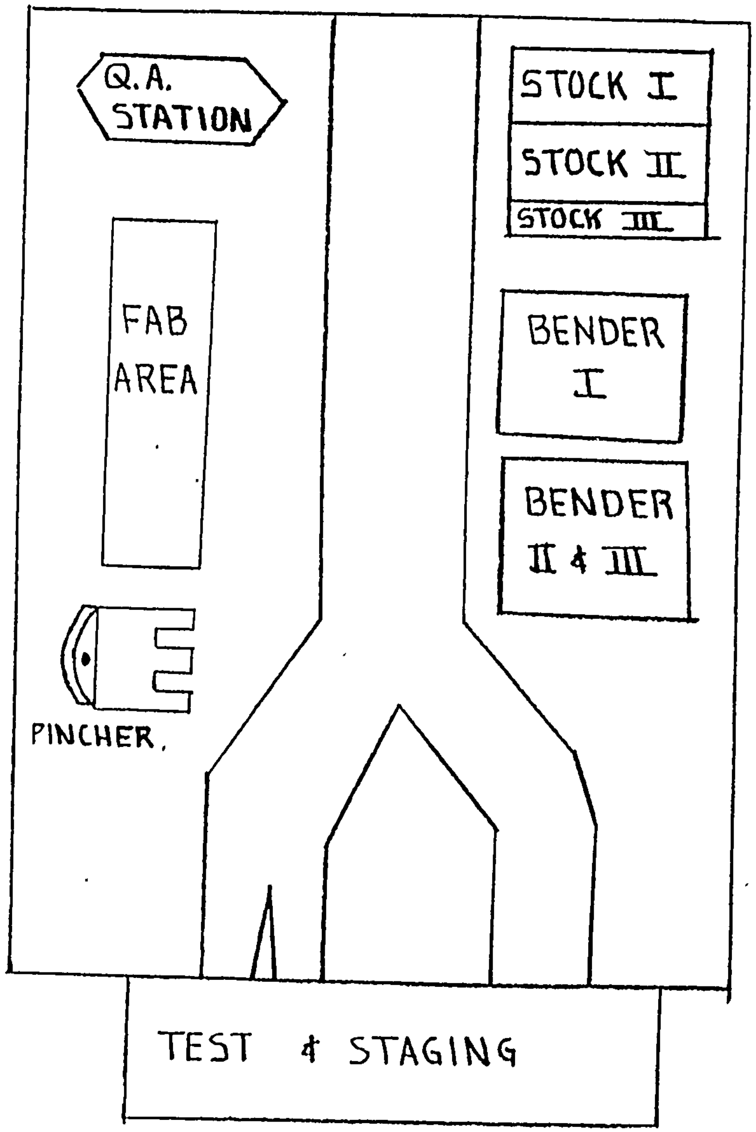
- *0* validate the model for accuracy,
- *0* recognize existing bottlenecks and limitations,
- *0* provide a vehicle for analyzing potential changes, and
- *0* establish a baseline of information for subsequent evaluation of the modified model.

Figure DSl depicts the vent shop layout and indicates some of the criteria for the simulation.

SIMULATION METHODOLOGY

A discrete event oriented model can best be used to simulate any environment where work occurs in isolated time periods. That is, if material (called "transactions") take finite amounts of time to travel (called "advancing") between storage (called "storage") and machinery (called "facilities"), then a model can be built to simulate that activity. Therefore, our vent shop model can be comprised of the following simulation entities:

ENVIRONMENT & MODEL OBJECTIVES



REPRODUCE EXISTING ENVIRONMENT

* CURRENT CONSTRAINTS
* THRUPUT
* FACILITY USE

ADJUST FUNCTIONS, ALGORITHMS, "TIMING", CONTROL DATA, ETC,

DETERMINE SHORT TERM SOLUTIONS WITHOUT DISRUPTING THE SHOP

. EVALUATE MAJOR CHANGES TO SUPPORT SALES POTENTIAL, SHIP'S SCHEDULE, PROFITS, ETC,

FIGURE DSl

0	Faciliites	Machines, check points
0	Queues	On-floor staging
0	Storages	Bins, warehousing, in-shop storages
0	Advances	Travel, dead, or wait time consumption
0	Savevalues	Accumulators for measuring quantity flow at any point in the shop's model
0	Gates	Management decision points
0	Matches	Gathering of material, labor, or management decision to continue a process. I.E., two pieces of vent and a Q.A. action coming together to build a subassembly.
0	Functions	Machine up/down time curves, manpower availability curves, raw material arrival rates, inspection rates by material class, Q.A. rejection rates by material class, etc., etc.

Figure DS2 depicts the same vent shop along with a partial representation of the simulation model for that shop configuration.

APPLICATION OF THE MODEL

Once a model is created which will simulate the existing environment, the model can then be modified in any manner conceivable to demonstrate potential changes to the vent shop, without actually spending large amounts of capital to actually upgrade the shop.

Thus, known material bottlenecks can be smoothed out without shutting down the shop for any required facility changes. The anticipated TO/TO demand can be placed on the model to determine just how well the actual shop will respond to the real demand. Proposed new machinery procurements can be simulated prior to purchase to determine whether or not that machinery will support the increased vent requirements.

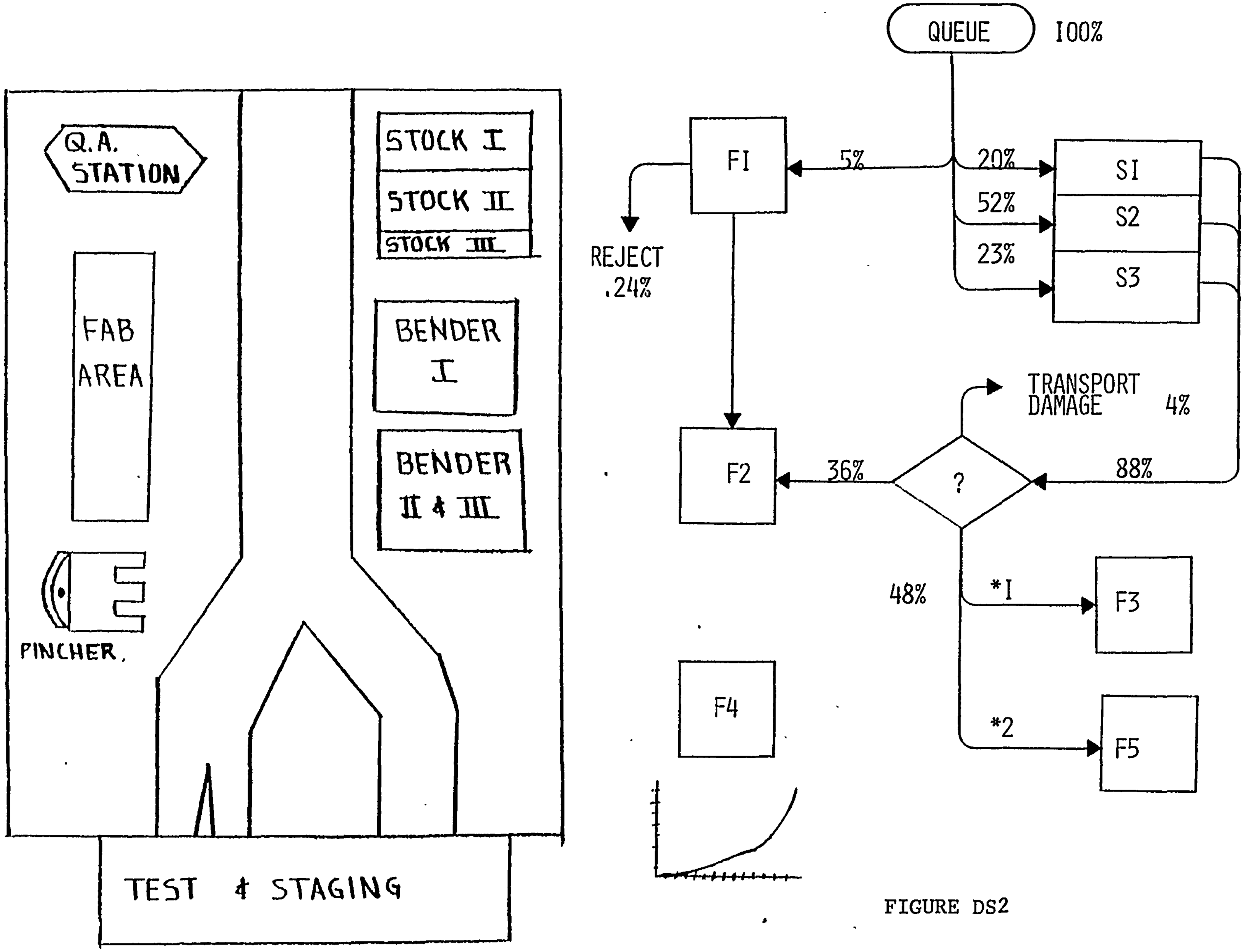

Q.A. STATION
FAB AREA
PINCHER.
STOCK I
STOCK II
STOCK III
BENDER I
BENDER II & III
TEST & STAGING
QUEUE
100%
FI
5%
20%
52%
23%
S1
S2
S3
REJECT .24%
TRANSPORT DAMAGE
4%
F2
36%
?
88%
48%
*1
F3
*2
F5
F4

FIGURE DS2

In addition, should vendor specifications for a proposed piece of machinery be doubted, the simulation can be instructed to downplay the performance of a particular machine. This is easily done by changing the machine's performance "function," thus causing more simulated down time, setup time, or processing time. Numerous simulation runs can then be executed to determine the optimum arrangements of machinery, both new and existing.

Material flow can be evaluated using the simulation model. Storage and queue sizes can be modified to reflect in-shop material staging. Material transportation can be isolated and studied by supplying more material handing capabilities, re-arranging the shop floor, improving handling techniques, or modifying the material expediting methodology. All of these can be done without actually disrupting the normal day-to-day working environment of the existing shop.

RESULTS OF THE SIMULATION

Figure DS3 depicts one possible output from the computer simulation exercise. Referring to the figure, we see a detailed presentation of "faciities" and storages." While the columnar titles do not reflect shipbuilding nomenclature, we can interpret the data as follows:

o Facility Average Queue Length

  The amount of material items in staging within the confines of the shop. For each "facility," this tells us how many items are waiting the use of each machine.

FACILITIES

	AVERAGE LENGTH	AVERAGE TIME	MAXIMUM QUEUE SIZE	MAXIMUM USE TIME	TOTAL ENTRIES
FI	24	2.3412	31	3,4561	42
F2	12	37.8375	22	4114503	3s
F3	0	25,1000	0	32,5000	120
F4	G	10,2388	0	12,0000	38
F5	31	18,2500	32	46,1285	201

STORAGES

	AVERAGE QUANTITY	MAXIMUM QUANTITY	AVERAGE TIME/IN	MAXIMUM TIME/IN	TOTAL IN	CAPACITY
SI	101	120	102,234	120,000	327	500
S2	I64	203	95,200	100,120	253	1000
S3	35	100	202,101	23.114	I5I	200

FIGURE DS3

- Facility Average Use Time

  The amount of time consumed by each facility during the simulated real time. We can observe the time constraints of each machine or inspection area over the time span of the simulation. Time of use based on material class can also be simulated by enhancing the model (not shown here).

- Facility Maximum Use Time

  Averages give nominal use only. Maximum values augment our information by demonstrating upper limits on the timing of the shop.

- Storage Total Entries

  This helps us to determine if adequate in-shop storage is available for the incoming raw stock. Note that the next column, "Capacity," is preset by the simulation analyst to reflect the absolute capacity of each storage bin for each type of material. Possible bottlenecks for material storage can thus be evaluated by comparing these two pieces of data.

One single simulation run would be insufficient to evaluate all of the possibilities for streamlining Noah's vent shop. Numerous iterations would be performed on the model, changing key items in an attempt to optimize the model, and its resultant shop configuration. Such an evaluation would require involvement from various departments on the yard, such as:

- Production
- Planning/Scheduling
- Facilities
- Material Control
- Engineering

The model's results, once optimized and evaluated against all of the known criteria which influences the yard, would provide the basis for new facilities, machine procurement, ship's schedule relationships, and management visibility. All of this was done on the computer, without impacting the current activities of that shop as construction continues on existing vessels.

CONCLUSION

Our presentation at the REAPS Symposium was intended to demonstrate two possible applications of Operations Research techniques to the shipbuilding industry. The contents of this paper reflects that presentation and explains some of the technical arguments in greater detail.

It is the contention of the authors that such technology is necessary in our industry in an attempt to improve the shipbuilding methodology, increase. productivity, and generally upgrade our discipline by employing state-of-the-art analytical concepts. Through conversations with others and our own observations, we conclude that little emphasis is placed on Operations Research in terms of being a viable tool within our computer systems.

All too often, the computer use is limited to writing payroll checks, performing general accounting, and attempting material control. More advanced uses, such as Project Management Systems or advanced Material Requirements Planning systems, are seldom found. There seems to be a definite split between the technology of the computer and the “romance of shipbuilding.”

Considering the predictions of the shipbuilding future, this industry must begin investigating and investing in such technology to insure our competitive position in the world-wide market.

THE SHIPYARD PRODUCT INFORMATION SYSTEM AS AN AID TO IMPLEMENTING MORE PRODUCTIVE STRATEGIES

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IIT Research Institute
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Mr. Martin is currently responsible for the management of the REAPS program, as well as other projects in computer aids to shipbuilding, computer aided design, and shipyard manufacturing technology. He has a degree in naval architecture and marine engineering from the University of Michigan.

His previous experience includes the development of computer graphics systems for ship design and lofting applications, software for marine transport system economic analysis and a software system for real time model test data acquisition and analysis.

The REAPS shipyards have recently endorsed the first phase of a long term project to specify, design and implement a Product Information System. It is anticipated that the eventual output of this project will be a photo type information system, consisting of a database and associated utility software, which will be useful to a variety of functions in the yard which record or supply technical and production-oriented product information. While this may sound like a substantial undertaking (and it is) the benefits of the use of such a capability are equally substantial. The purpose of this presentation is to highlight some of the more significant of these benefits.

First we need to look at what is meant when we talk about a Product Information System for shipbuilding. The heart of the system is a logically-structured, product-oriented database which we call the product model. The phrase "product model" is perhaps a bit of a misnomer because, as we'll see, information about the yard itself is also maintained. In fact the linkage between product and yard facility information in the database is the source of one of the most important benefits of the Product Information system.

The product model consists of a set of so-called "logical models" which represent logically complete database subsets tailored to the needs of specific yard functions.

For example, there would exist a structural design model, design models for various distributive systems, a material control and production control model, etc. Each such model can be explicitly linked to, or overlap, other models in the database where there is benefit in doing so. This is another major source of benefits of the product model approach. Fig. 1 depicts the basic constituents of the Product Information System.

In order to depict models of information we have settled on the notation shown in Fig. 2 wherein the boxes represent entities or items about which we want to record information, such as parts of drawings, and the arrows represent relationships between entitites. The counterpart of an entity in a database can be considered to be a file of information that contains a series of records each of which holds information about a specific instance of the entity, as for example a specific part. Relations are represented by pointer chains in the database linking specific records in the entity files.

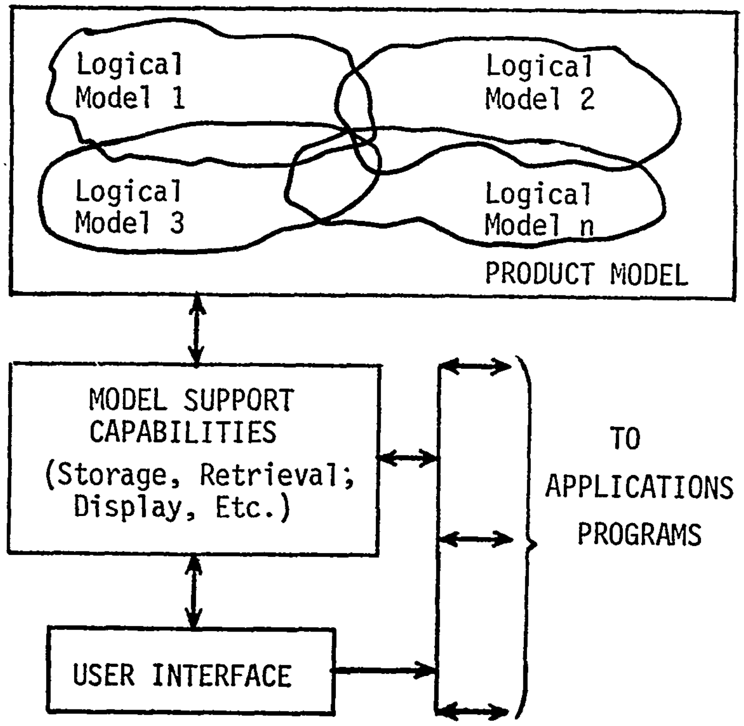


Figure 1. Product Information System Layout

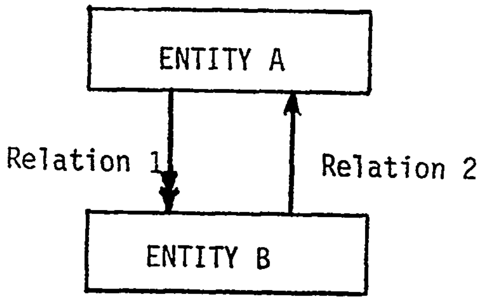


Figure 2. Information Model Notation

In Fig. 2 the double arrow pointing to entity B indicates that many B's may be related to a single entity A via relation 1 while the single arrow indicates that at most one A is related to a single B via relation 2.

Now lets look at some of the payoff areas for the use of a Product Information System.

Benefits in Design

The benefits of using a database approach to record the design fall largely into two categories: first, the improved ability to manage the design configuration and second, the increased speed and accuracy with which design documentation can be produced.

The major purpose of design information models is to document the physical characteristics of the design; in particular its geometry, arrangement and material requirements. To demonstrate how this might be done Fig. 3 represents a simplified design model for structure.

The principal component of this model is the Structural Definition Entity (SDE). An SDE may be a point, a line, surface, a volume (or region), a plate part, a stiffener or a group of parts. Material type is recorded for stiffeners and plates separately such that they can be easily collected to determine total material requirements. Non-derivable geometry for lines and surfaces is maintained in the Geometry Directory. Geometry that can be derived is not recorded explicitly until a formal approval is issued. This reduces database size and simplifies the task of making design changes.

Drawings showing several SDE's can be defined and subsequently produced (by a drawing processor) automatically. We can also record for each SDE the defined Drawings it appears in such that when changes are made to any SDE we can automatically determine which drawings are affected and therefore may need to be regenerated, thus simplifying design management.

The structural arrangement is recorded by means of stating the, geometric or piece Boundaries of each SDE in terms of other SDE's. For structural pieces bounded by other structural pieces a Joint is also defined which may reference a line SDE to specify the geometry of the joint.

Stiffener end boundaries may reference an executable Procedure, similar to current N/C system norms, which defines stiffener end cut geometry. In fact the geometry of plated parts, in particular brackets, may be entirely defined by such a procedure reference.

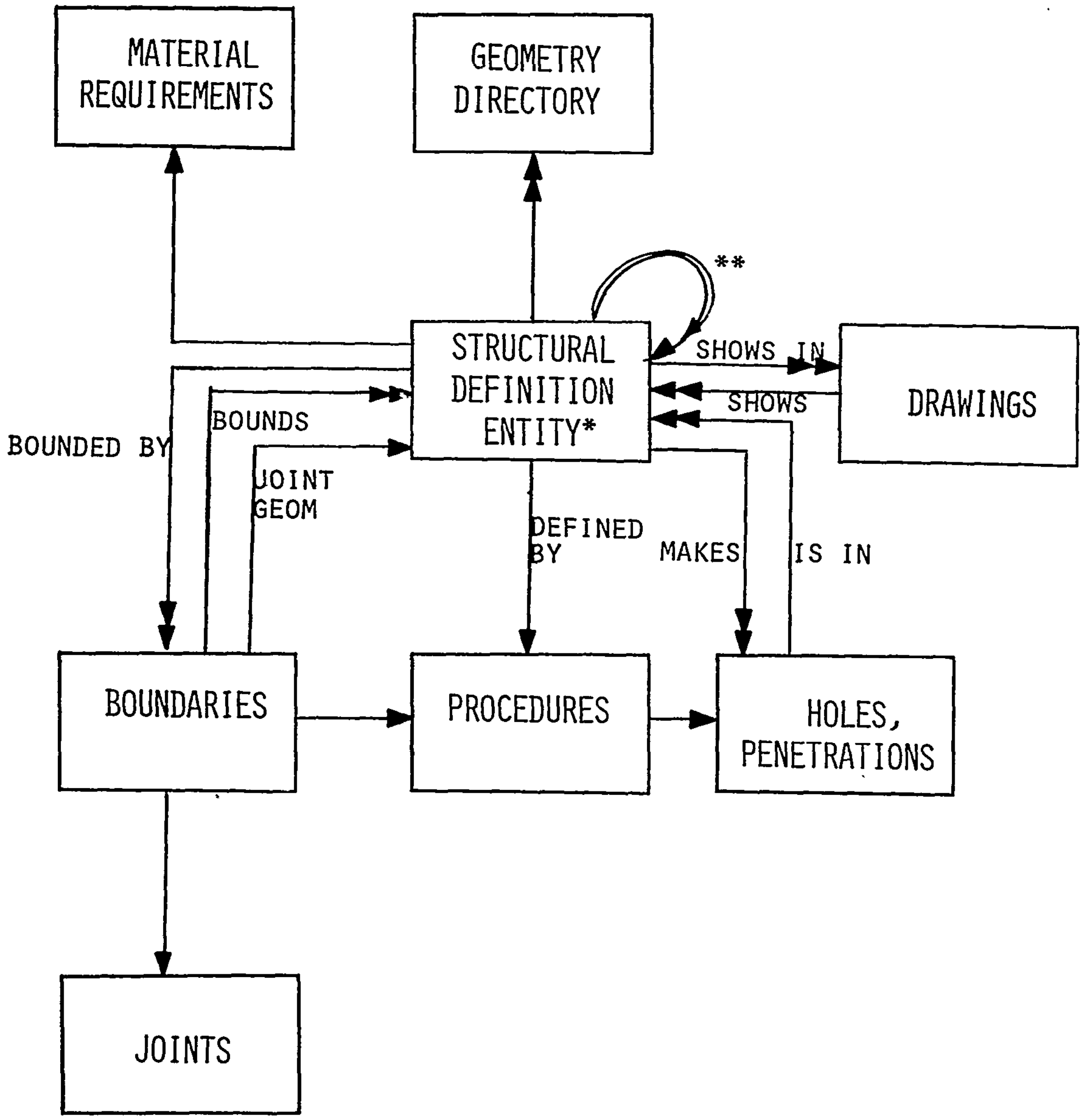


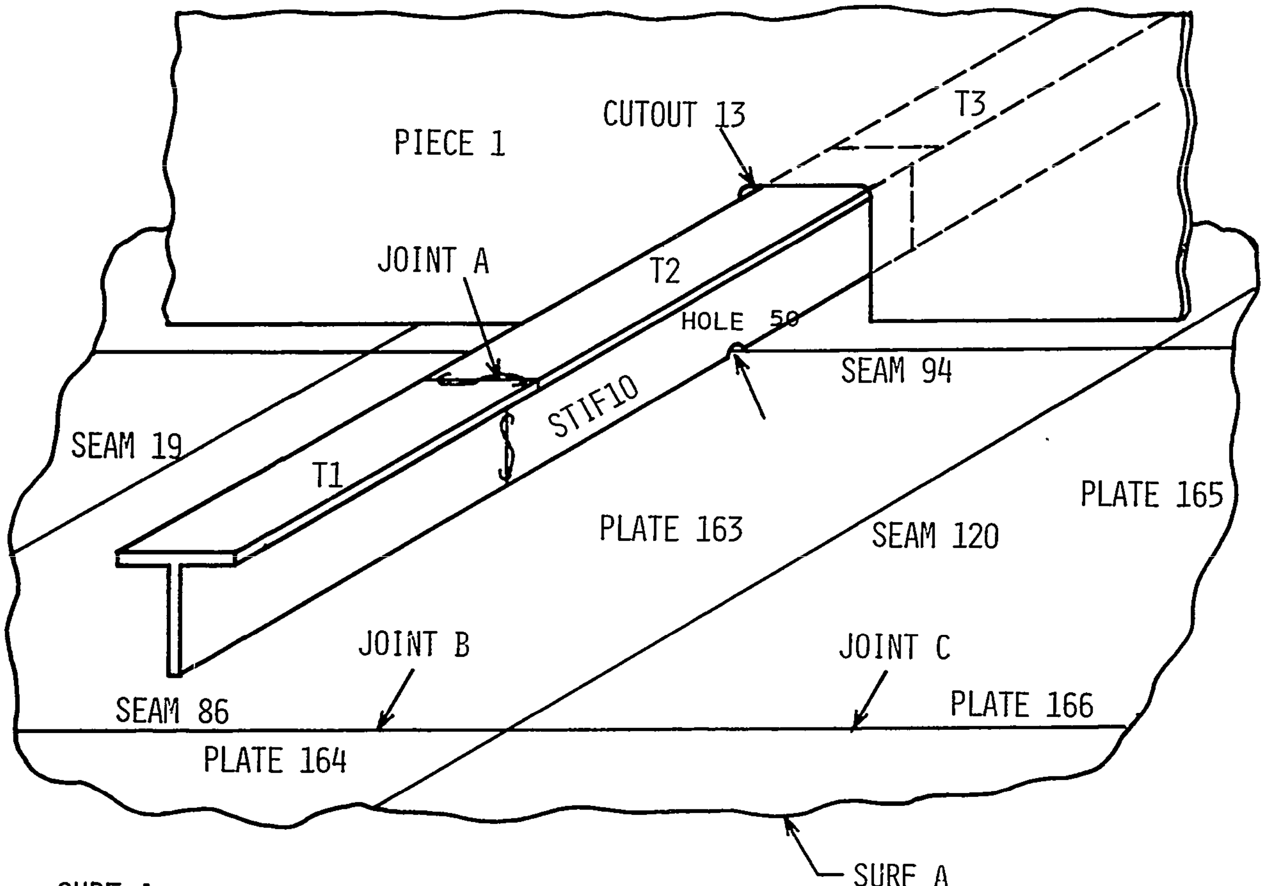
FIGURE 3. SIMPLIFIED STRUCTURAL DESIGN MODEL

* POINTS
LINES
SURFACES
VOLUMES (REGIONS)
PLATE PARTS
STIFFENERS
GROUPS

** CONTAINS; IS PART OF
TRAVERSED BY
REGION CONTAINS
GROUP CONTAINS
SYNONYMS FOR
IDENTICAL TO

Finally the holes in structure created by an SDE are recorded which results in the automatic recording of all holes in a given structural entity. The geometry of such holes may be specified by a Procedure.

Fig. 4 illustrates the usage of the relations which document the structural arrangement.



SURF A:

- CONTAINS PLATES 163,164,165,...
- BOUNDS PIECE 1, STIF 10,
- IS TRAVERSED BY PIECE 1, STIF 10

PLATE 163:

- IS PART OF SURF A
- IS BOUNDED BY PLATE 164 MAKING JOINT B WHOSE GEOMETRY IS SEAM 86

STIF 10:

- CONTAINS T1,T2,T3,...
- MAKES CUTO 13 IN PIECE 1, HAS HOLE 50
- IS BOUNDED BY SURFA,...

T2:

- IS PART OF STIF 10
- IS BOUNDED BY T3 AND T2 (CREATING JOINT A)

Similarly, a design information model for piping has been developed for use in the RAPID Pipe Detailing System and is depicted in Fig. 5. The primary entity in this model is the Part which may be a pipe piece, valve, fitting or piece of equipment. Parts may be grouped to include for example all those within a system or those within a manufacturable detail. Standard valves and fittings are defined

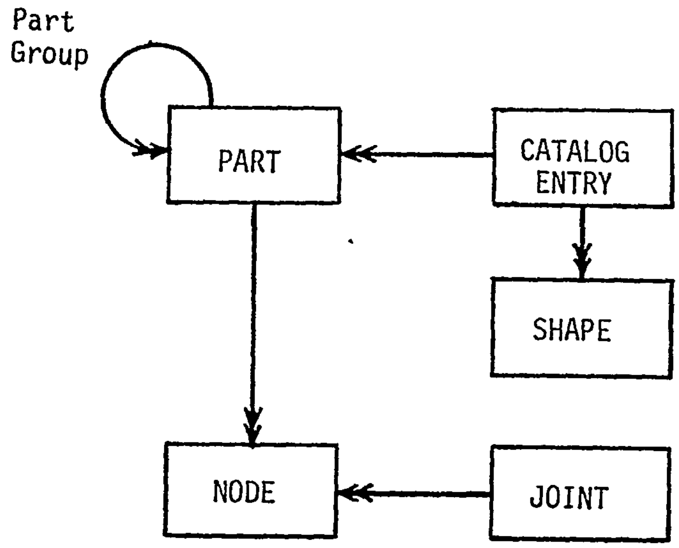


Figure 5. RAPID System Information Model

in a catalog and their use as unique parts in a system is recorded by the Catalog-Part relation. Each Catalog entry may be represented by several Shapes for drawing purposes. Part location and orientation is defined by Node entities which also serve to locate the position of internal reference points such as bend locations, hangar attachment points, sleeve locations, etc. The two end nodes of attaching components are referenced by the Joint entity which records the particular joint detail.

Fig. 6 depicts the data structure that would be created within this model to represent a simple detail.

Similar models could be defined to represent other systems and outfit items. Once these models are defined the relations to link them could also be established This linkage would offer the opportunity to perform interference checking, either in a semiautomated or completely visual way by producing composite drawings in any desired view, and to record penetrations through and attachments to structure created by the various systems. One could also define a relation for compartments

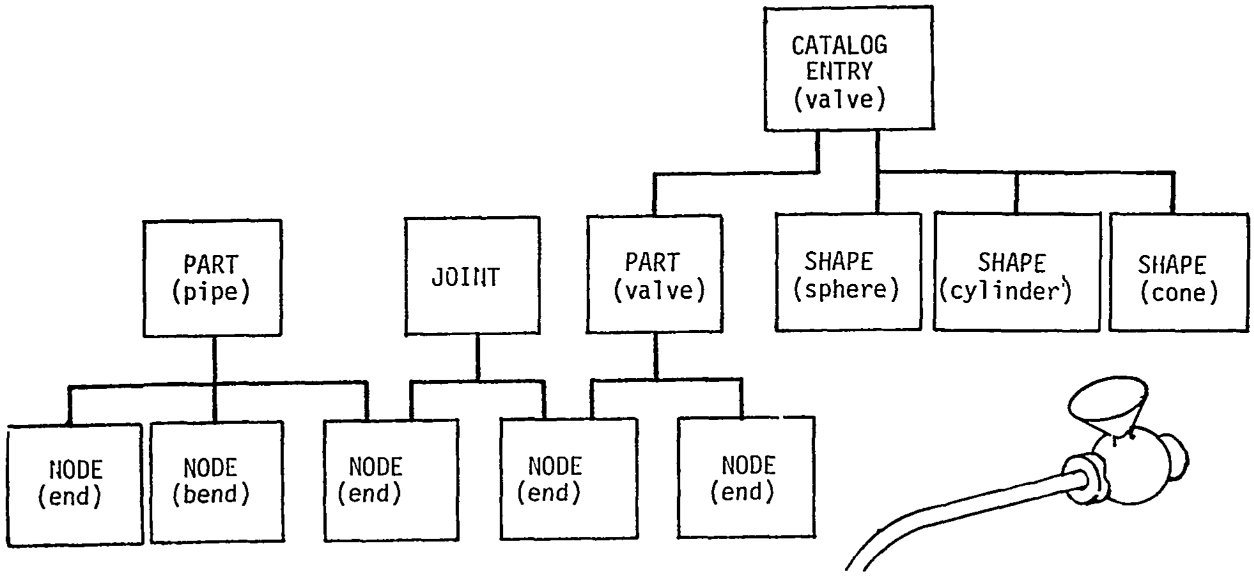


Figure 6. Example Instance of Piping Model

and spaces which identified all system components, pieces of equipment as well as furniture within them for the purposes of verifying contract-specified equipment lists for the spaces and automatically producing space arrangement drawings for early owner approval.

Fig. 7 summarizes the benefits in design of the use of such models.

1. ABILITY TO AUTOMATICALLY PRODUCT DESIGN DOCUMENTATION (DRAWINGS AND LISTS)
2. ABILITY TO REVISE DESIGN QUICKLY AND MANAGE DESIGN CONFIGURATION MORE EFFECTIVELY.
3. LINKAGE OF VARIOUS "SYSTEM" MODELS PROVIDES THE INFORMATION BASE FOR INTERFERENCE CONTROL.
4. USE OF STANDARDS WOULD BE ENCOURAGED.

Figure 7. Design Benefits Summary

However, the most important feature of these models is that they document the design completely for use by other yard functions in terms of its material requirements, its physical arrangement and the parameters of the design which define its work content (such as square footage for coating, joint type and length for welding and cutting path lengths for burning, etc.). As this information is collected, material control can access it to acquire material requirements for issuing purchase orders, and planners can access it to begin defining production units (or interim products) and to define and schedule work packages.

BENEFITS IN PLANNING

The first payoff for planning (i.e., tactical production planning as opposed to strategic or long range planning) is the availability of the current design definition on a computer as opposed to on pieces of paper in the form of drawings and lists. As a result, early stage planning of structural units could benefit by being able to slice up the design in various ways and produce computer-generated drawings of the defined units for all desired views. Figures 8 and 9, taken from [5] show the type of product visualization needed at this point in planning. This would aid greatly in determining the producibility of the unit and aid in planning material handling requirements for turn overs as well as lifting, as the weight and center of the candidate unit would be directly available from summing these parameters for the design-defined components it contained. Several options for unit configuration could be reviewed quite quickly in this way.

Later on in Structural Planning the object is to develop a fabrication plan which makes effective use of shop facilities and labor while meeting a production schedule dictated by the sequence of erection. These two goals may be conflicting as pointed out by Ruehsen [5]. As one of the planner's greatest handicaps currently is lack of detailed product and facility information he generally will elect, justifiably, a conservative plan and accompanying schedule as a hedge against this uncertainty.

The planner needs to know as much as possible about the projected loads on fabrication shop facilities, the assembly unit product structure and schedule, and the material requirements of the components in these units in order to develop an effective fabrication plan and schedule. The product model could supply this information and allow the planner to "try out" several alternatives prior to committing to a plan and schedule. For example, various nest arrangements and sequences could be quickly evaluated, including cross unit nests, trading off the need for

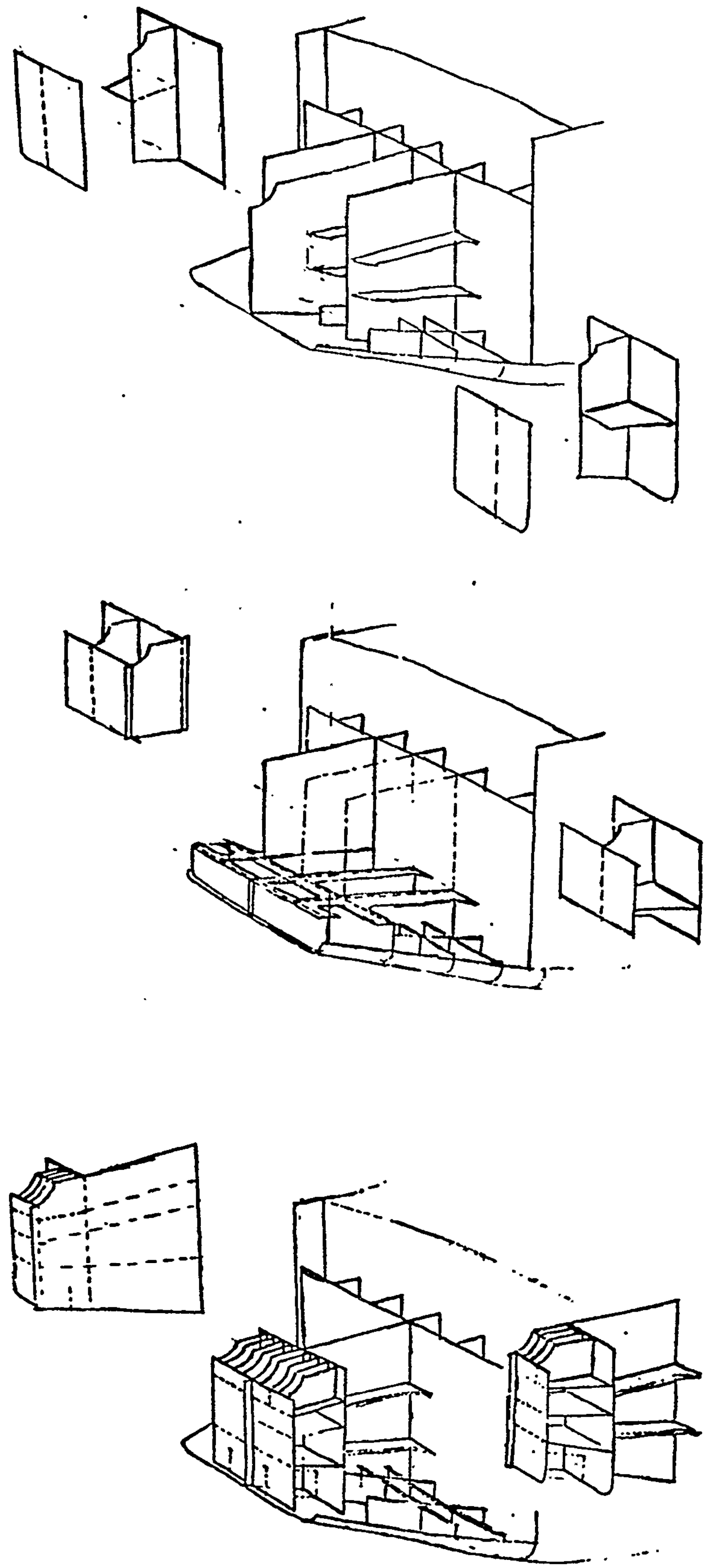


Figure 8. Hull Planning Graphics

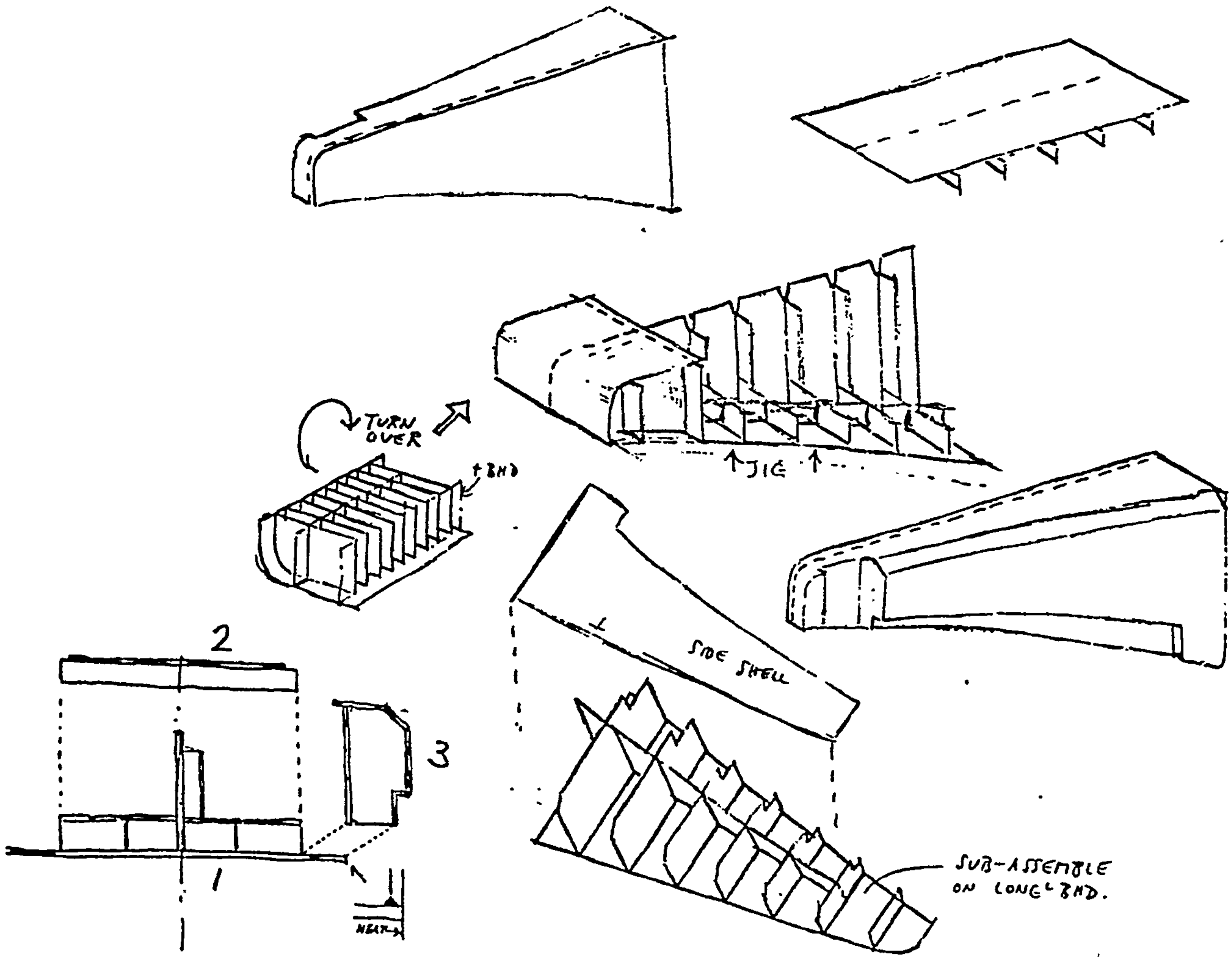


FIGURE 9. Assembly Planning Graphics

in-process material buffer storage against efficient material usage, handling and shop loading.

Fig. 10 depicts a simplified information model for structural production which depicts the major information entities and relations the planner needs to make use of.

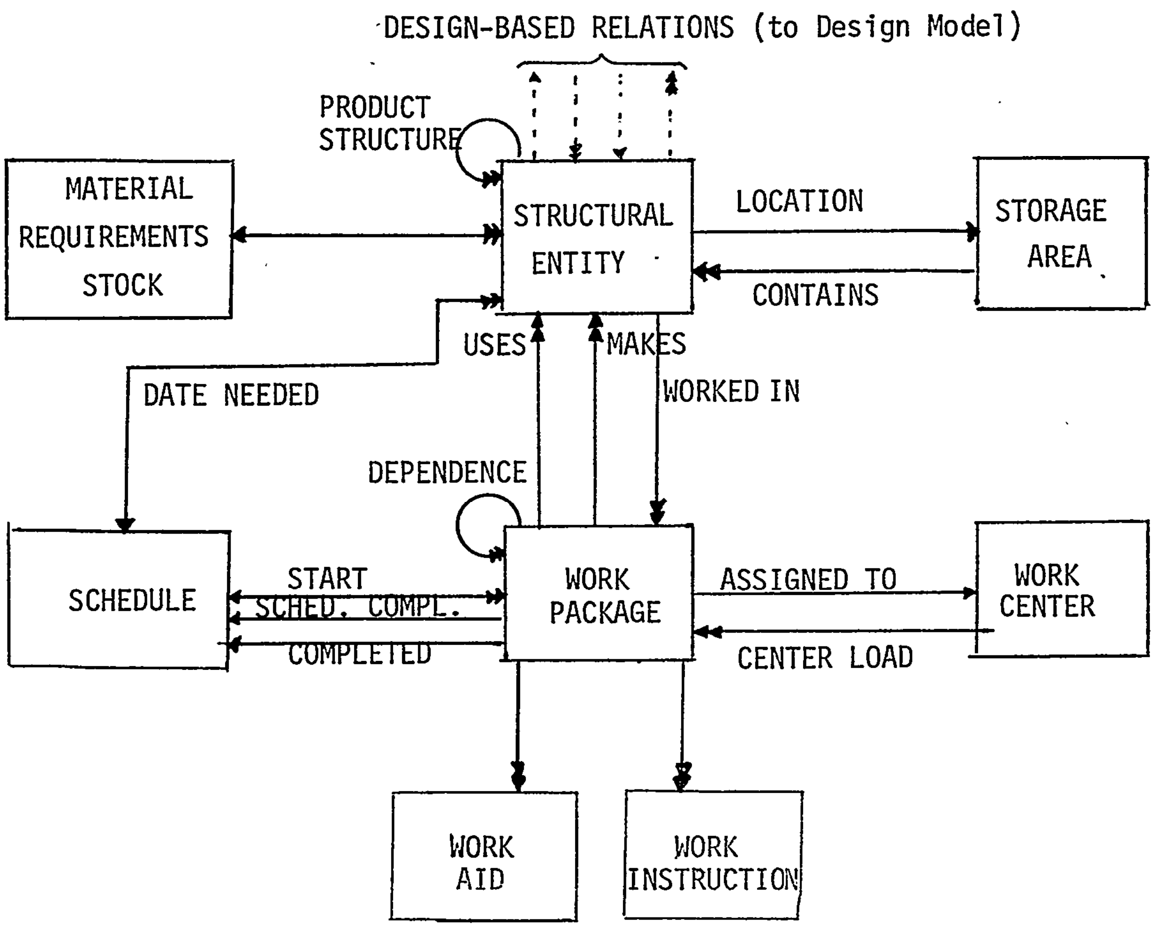


Fig. 10. Simplified Production Model

In this model "Structural Entities" are initially the set of individual parts resulting from detailed design, requiring fabrication and subsequent assembly. Each such item retains its identity in terms of the structural design through its linkage, via the "Design-Based Relations" to the structural design model. Also, each structural item at the component level to be fabricated will require a particular stock type, thus, Its relation to "Material Requirements".

Given component-level parts and their material requirements as a starting point the planner can begin to "build" the assembly "Product Structure", identifying those items contained in a subassembly, subassemblies in an assembly, etc. while defining a 'Work Package" to accomplish each assembly job (which would identify the components it "Uses" in creating the assembly it "Makes"). Each work package once fully designed, would have associated with it the "Work Aids" it required (e.g. N/C tapes, jigs, molds, sketches, etc.) and the "Work Instructions" (e.g. assembly sequence, welding process, dimension checks, etc.) needed to carry it out. Those packages which must be completed prior to initiating the current package could be identified via the "Dependence" relation.

The planner could then identify a tentative assembly schedule noting the "Date Needed" of the completed item (based on the erection schedule), and from this estimate necessary "Start" and 'Scheduled Completion" dates for the candidate work packages.

Fabrication work packages and tentative schedules could be subsequently defined. Such packages could "Make" one part (e.g. a shell plate) or many parts (e.g. through cutting a nest). The nesting job itself is aided by the relation identifying all parts of a particular material type, their needed dates and the product structure relation. These relations could be used to perform a composite search of the data to return that set of parts, of a particular material type, required by a given date that are included within a specified set of assemblies or units. From this list of parts a set of fabrication work packages could be developed, and their accompanying schedule assigned.

Each work package would be "Assigned To" a particular "Work Center" and the group of all work packages assigned to a particular center identified, via the "Center Load" relation, thus providing the basis for assessing facility loads.

Making use of an information base such as that of Fig. 10 the planner then could try out various product structure configurations and candidate work package definitions and schedules in an attempt to develop an efficient structural production plan. Projected work center loadings and 'Storage Area" inventories could be assessed quickly during this process to determine uneconomic or infeasible situations. The end result of this process would be a production plan based on the best available information, which would reside on the computer ready for use by production control.

Therefore if a yard does elect to nest on a unit basis, or schedule fabrication jobs which are closely tied to the erection schedule, it ought to do so because these strategies will lead to the most cost or time effective production. It need NOT do so because a lack of information makes any other plan too risky or too cumbersome to manage.

The next benefit for the planning function comes not from the use of a product model per se but from inclusion within the model of engineered standards data. For our purposes these standards which are discussed in some detail in [4], produced by Bath Iron Works under the auspices of the National Shipbuilding Research Program (NSRP), document standard labor budgets and job durations for those processes and operations for which they have been established in the yard. One of the primary objectives of using such standards is to produce more reliable work package schedules; that is to reduce the variance in work package labor budgets and duratiors as depicted in Fig. 11 taken from the Bath report [4]. Quoting from that report:

> "Both early and late work package completions have unfavorable impact on construction costs. Work that is completed early must be stored, thereby incurring unnecessary material handling costs and inventory carrying charges. Work that is completed late usually entails expediting and overtime costs. Reducing the variance of work package duration distributions will permit tighter scheduling of work, thereby reducing the cost of early and late completions, as shown in ... "(See Fig. 11). This is a primary objective of improving the accuracy and reliability of the planning and scheduling process. In order to do that however, a firm and reliable basis is needed for determining the amount of real work in each package and how long it will take to accomplish it. Planning and scheduling can be tightened up ONLY if such a basis exists. Otherwise the plan will simply misrepresent the real duration, and scheduling will be even less credible than it was before."

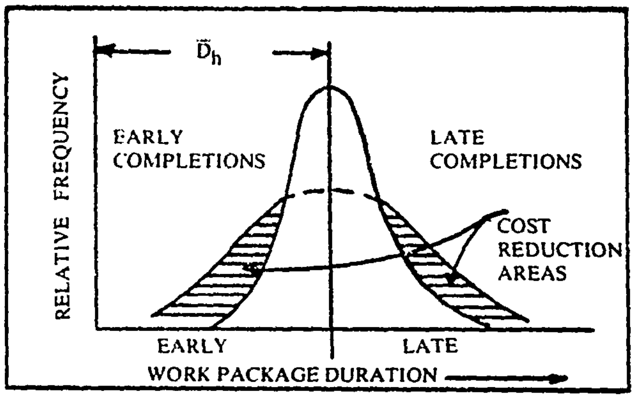


Figure 11. Benefit of Compressing Dispersion of Work Package Duration

Given the availability of such standards in our product model, and having already recorded the pertinent design parameters used in applying these standards, work package labor budgets and durations could be automatically calculated. These estimates could then be used to establish the schedule.

Fig. 12 depicts an information model that would support this process. (The use of this model is discussed in the next section.)

Additionally, provided a suitable scheduling program was available, the schedule itself could be automatically or semi-automatically determined as a result of executing a strategy to level-load facilities and/or manpower.

OUTFIT PLANNING

Fig. 12 was generated originally to document how a Product Information System could support the processes of "Outfit Planning" [6] again produced within the NSRP and sponsored by Todd Pacific Shipyards.

Without going into detail the major objective of the outfit planning methodology, as practiced by some of the most competitive yards in the world, is to plan the production and assembly of outfit units in shops for the purposes of:

- o achieving shorter contract award to delivery times
- o reducing total cost
- o achieving better quality
- o improving worker safety

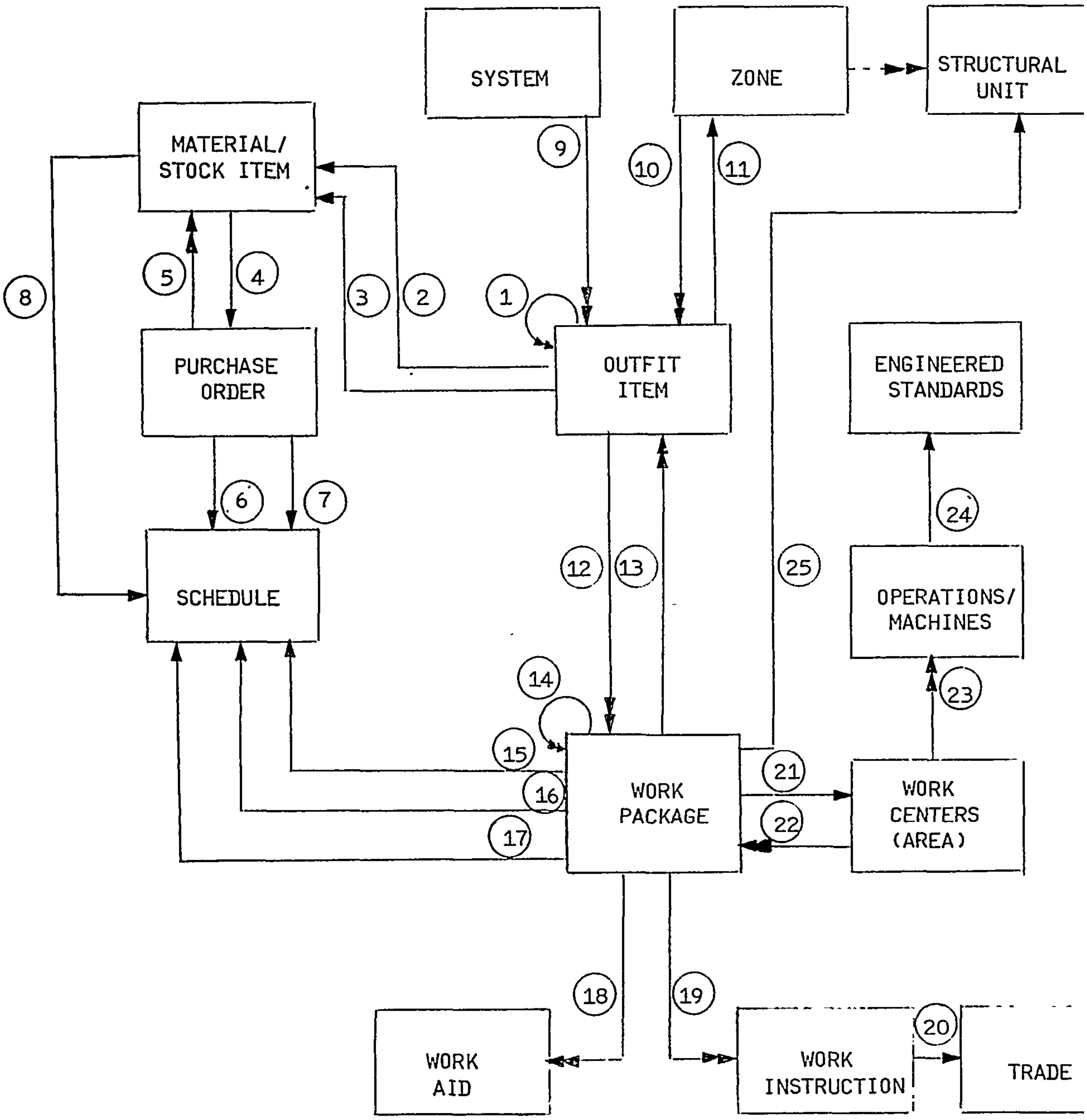


Fig. 12. SIMPLIFIED OUTFIT PLANNING/PRODUCTION DATABASE

Three rather key features of the methodology are that the outfit design and planning functions are intimately linked, that they are linked because their principal product is the definition of modular, sometimes multisystem units called "interim products", and that the design and planning of these units is controlled largely on the basis of geographical regions in the ship called zones.

The fundamental entity in the model in Fig. 12 is the Outfit Item. This may be a single component (e.g. a flange fitting) or the collection of components via 1, composing an outfit "unit". Component-level items may be purchased stock items (e.g. the flange), 2, or components fabricated from raw stock (e.g. a pipe piece or HVAC duct) 3. (Purchased stock items could be additionally classified, as is done at IHI, as renewable inventory stock or "allocated" stock material.)

Each Material Item procured on a contract basis appears on a purchase order, 4, and each purchase order may reference many items 5. Each P.O. is related to the Schedule via the date of its issuance 6 and the planned receipt date 7. Each Material Item also has recorded about it its actual receipt date in the yard 8.

A System (defined in design) is composed of many component-level items 9. Similary each Zone may contain Outfit Items, component-level or not 10, while each unique Outfit Item will be located in a single Zone 11 (although the particular Zone it is in many change over time as Zone definitions change.)

An Outfit Item may be called out in more than one Work Package 12 (as long as it is not physically transformed) and a particular Work Package may reference many Outfit Items 13 as in an assembly operation.

A Work Package's dependency on the completion of other packages can be stated 14 along with its "start", "needed" and "completed" dated 15, 16, 17.

A Work Package may require several Work Aids 18 such as jigs, templates, shop sketches etc. and may consist of a series of individual Work Instructions 19. Each instruction could reference the Trade used to carry out the instruction 20.

The Work Package is assigned to a particular Work Center (Area) 21 and each Work Center may at any given time have several Work Packages scheduled for it 22. A Work Center may utilize several machines and many operations may be carried out 23. An Engineered Standard may be established for each operation@. Finally where an Outfit Item is to be installed "On-Block" a relation 25 is needed to identify the particular structural unit into which it is to be integrated.

As previously mentioned the design-oriented product description is directly linked to the production-oriented description. As a result design-specified information which serves as input to work content-estimating relationships based on engineered standards application (e.g. area of surface to be coated, length of welded joints for various processes, number of flanged joints to be bolted, etc.), is directly available. Therefore labor budgets and total process times may be automatically computed for each work package, from which work center loads may be automatically totalled. Rescheduling can then be performed to level load facilities and manpower.

One potentially difficult material control problem arises as a result of this methodology's emphasis on compressing outfit duration (really total contract duration) and the dual role played by outfit items as system components and work package or "pallet" components. The problem involves keeping track of those items (or their source materials) which have been ordered early on (or are already available in inventory), on the basis of preliminary system material lists, and those needed in a interim product-based work package material list which have not been ordered or are not available in inventory. The simple information structure in the model of Fig. 12 would eliminate any confusion in this regard.

The methodology of Outfit Planning truly offers the potential for dramatic productivity improvements and we believe the availability of a product model such as this can significantly assist in its implementation and execution.

Fig. 13, then, summarizes some of the effects on the planning function of the use of a Product Information System.

BENEFITS IN PRODUCTION CONTROL/PRODUCTION

As we have already seen the use of engineered standards in the product model allows reliable schedules to be established from solid work content estimates for each work package. This by itself would simplify production control as there would exist much less variance or exception conditions requiring control in the first place.

BENEFITS IN PLANNING

1, EASE WITH WHICH THE DESIGN CAN BE DECOMPOSED INTO UNITS AND EVALUATED FOR PRODUCIBILITY, ETC.

2, POTENTIAL FOR AUTOMATED LABOR BUDGET AND JOB DURATION ESTIMATES GENERATION FOR SCHEDULING BASED ON DESIGN DATA AVAILABILITY AND THE USE IN THE PRODUCT MODEL OF ENGINEERED STANDARDS.

3, PROVIDES TOOL FOR SUPPORT OF OUTFIT PLANNING.

Fig. 13. Planning Benefits Summary

Where exception conditions do occur, such as when a major piece of equipment goes down for a prolonged period, the ability to reload facilities and manpower and reschedule work packages quickly to achieve level, or minimum cost loading would be very beneficial. This reloading and rescheduling could be carried out as often as the yard felt necessary.

The benefits for the shops themselves come more or less for free as a result of the fact that a more complete design and planning job can be accomplished prior to their receipt of a work order and due to the fact that the jobs are issued in accordance with a schedule which is based on better-informed decision making by production control.

However the shops should benefit as well by receiving computer-generated job documentation which is accurate and which can be customized easily to meet each shop's and, if necessary, each job's particular requirements. As an example Fig. 14 represents an unit isometric which could be computer-generated to supplement the assembly work package for the unit. Fig. 15 summarizes some ofthe benefits for production control and the shops of the use of a Product Information System.

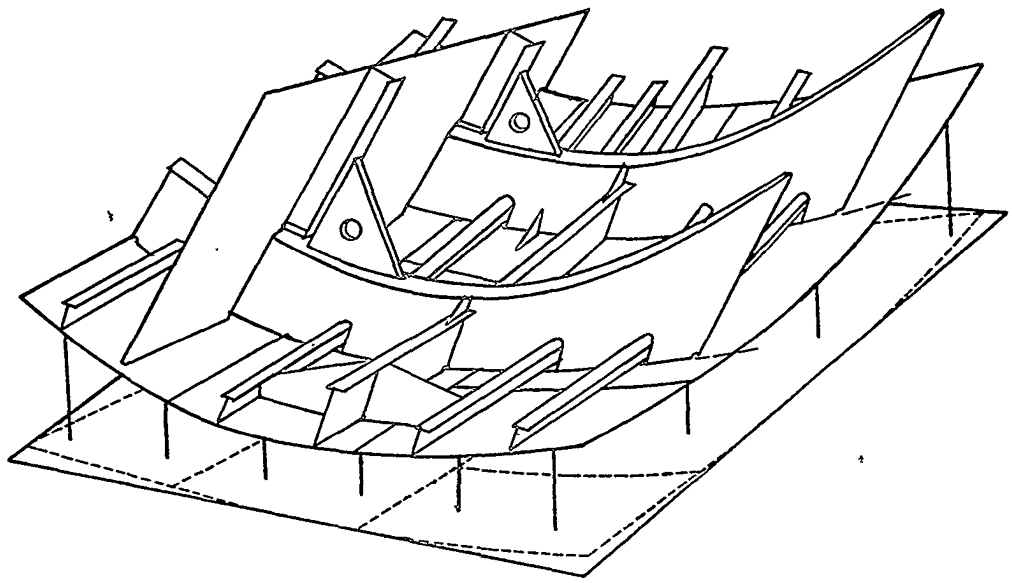


Fig. 14. Example Unit Isometric Shop Sketch

BENEFITS IN PRODUCTION CONTROL/PRODUCTION

1, MORE RELIABLE SCHEDULES DUE TO APPLICATION OF ENGINEERED STANDARDS,

2, ABILITY TO AUTOMATICALLY LEVEL-LOAD FACILITIES AND MANPOWER,

3, ACCURATE WORK PACKAGE BILL OF MATERIALS DIRECTLY AVAILABLE--UNAVAILABILITY OF AN ITEM CAN BE AUTOMATICALLY FLAGGED,

4, COMPUTER-GENERATED SHOP SKETCHES CAN BE TAILORED TO PRODUCTION NEEDS,

Fig. 15. Summary of Production Control/Production Benefits

Summary

To summarize, a product model is all about properly organizing information. The fact that its on a computer simply means that those that need to use it can get it quickly and in a useful form; and that application programs can readily access it.

In terms of implementation any commercially available data base management system which supports network information structures is capable of accommodating such product models. Because of the use of such off-the-shelf database software it would be a straightforward task to interface existing applications software to the product model, thus enhancing each yard's current investment in their operational software.

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SEMI-AUTOMATIC PIPE PRODUCTION IN A SMALL SHIPYARD

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This paper has been written with the small shipyard in mind, and to comment on its approach to large new piping systems incorporating the latest developments in production equipment and computer aids. Small yards face a common problem when confronted with large systems together with their associated software packages and extensive hardware requirements for both computers and production equipment. The obvious common problem is the volume of throughput and the need to generate sufficient savings to justify the level of investment required. Even if theoretical savings were sufficient, it is unlikely that a small yard would have sufficient resources to successfully incorporate all the changes in ***one*** step.

In recent years a number of small yards have introduced large computer systems for N.C. steelwork (eg. Autokon System) by taking a step by step approach to its installation, and it is appropriate that their attention should now turn to the next largest labour intensive process in ship construction - that of pipework.

Recent changes in pipework processing range from the fully automatic integrated systems, through various levels of semi-automatic systems with computer aided design or computer aided construction.

A shipyard has a number of choices it can make regarding its pipework: -

a) A fully automatic system supported by comprehensive computer programs

b) A semi-automatic system supported by computer programs

c) A computer aided piping design system

d) A computer aided piping construction system

Large systems that incorporate fully automatic production equipment on the shop floor supported by computer programs for pipe design and pipe production data, offer the largest potential savings, but are necessarily expensive and beyond the budget of a small shipyard. These large systems such as Mitsui's Maps System, Hitachi's Hicas System or Germany's Oxytechnic System do, however, have component systems that could be used as a basis for a small yard semi-automatic application with a minimum of cost and a rate of return that would justify the investment.

It should be noted here that reference made to "semi-automatic" in this paper is not intended to indicate a processing system that is half automated, but rather to indicate that some of the equipment involved has some automated features that can be supported by computer aided design or computer aided construction programs.

When faced with the variety of choices, the dilemma we faced, as a small shipyard, was - on which piping system would we concentrate our limited resources? Since the ratio of production manhours to drawing office hours for piping

systems approaches 5:l it was decided that the first place to invest money was on the pipeshop floor. The semi-automatic equipment purchased in Port Weller included the following: -

l - pipebender, 2 X D bends for 21/2" - 8" pipes
l - pipebender, 2 X D bends for 1/4" - 2" pipes
1 - pipe profiling machine with analog control for pipes up to 40" dia.

We-are currently investigating: -

1 - pipe flanging machine for use with loose backing rings on pipes up to 8" dia.

By installing this equipment, with or without supporting computer programs, some basic costs of steel pipe fabrication can be eliminated. For example, Fig. 1 shows a comparison of 2 sister ships recently built in Port Weller.

Fittings Purchased *	Sister Ships	
	Ship No. 1 No. of Fittings	Ship No. 2 No. of Fittings
1. Standard weight, 90° and 45°, LR & SR Butt weld elbows: size l0" to 16" inclusive ---- - size 8" and under---------.	 88 173	 11 0
2. Standard weight, straight & reducing tee's size. 10" X 10" X 10" & under,--	18	1
Total No. of fittings	279	12
Total value of fittings	$ 14,271.	$ 1495.
* Ship No. 1 constructed without bending & profiling equipment Ship No. 2 constructed with bending & profiling equipment		

Fig. 1 Fittings required for Bilge & Ballast System I.M.S. for 30,000 Ton Bulk Carrier

The first ship was constructed before the purchase of bending and profiling equipment, the second ship was constructed using the equipment. The elbow and tee fittings required for the manual construction of the Bilge and Ballast System I.M.S. are listed, and are compared with the fittings required for the semi-automatic fabrication. As shown - 95% of the fittings were eliminated in this system.

This type of saving is applicable to other systems, and 5 major systems are shown in Fig. 2. The total cost of. fittings eliminated on a vessel of this size approaches $40,000. Spin-off savings are encountered in reduced purchasing and storing requirements.

System	Sister Ships	
	Ship No. 1 Cost of fittings	Ship No. 2 Cost of fittings
Bilge,Ballast I.M.S.	$ 14,271	$ 1;495
Diesel Exhausts	6,257	
R.W. Circulating	5,546	45
Lub Oil System	3,035	175
Fuel Oil System	2,809	244

Fig. 2 - Reduction in use of elbows & tee's for major systems of 30,000 Ton Bulk Carrier.

The material savings are quite large in themselves, but take on more significance when one considers that they

do not need to be welded into the system. Take, for example, a typical day's production on a bending machine with 8" dia. pipe. If 2 hours are allowed for a tool change, a bender operator could, on average, produce 24 machine bends in the remaining 6 hours. The approximate cost of these 24 bends would be as follows: -

16 hrs labour @ $8./hr =	$128.	(machine,is operated by 2 men)
pipe material in bends =	384.	
TOTAL	$512.	

The equivalent cost using elbows would **be: -**

24 X 8" dia. elbows =	$ 864.	
welder labour costs =	475.	(manual welding)
TOTAL	$1339.	

Incidental costs have been left out of both the above calculations. The ratio of costs - elbows:pipebender is approximately 2.62:1.

A similar analysis of 5" pipe gives the following results. Once again 2 hours are allowed for a tool change '(worst case 8" to 5" dies). In the remaining 6 hours an operator could, on average, perform 36 bends.

16 hrs labour @ $8./hr =	$128.
pipe material in bends =	225.
TOTAL	$353.

The equivalent cost using elbows would be: -

24 X 5" dia. elbows =	$ 697.
welder labour costs =	447.
TOTAL	$1144.

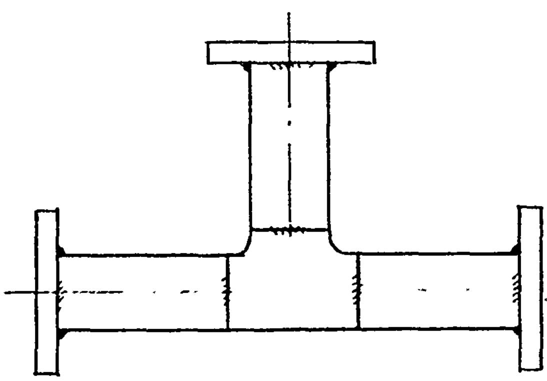
Once again, incidental costs have been left out of both calculations and the ratio of costs elbows:pipebender is approximately 3.24:1.

These ratios increase as the pipe gets smaller, especially 2" dia. and below, as the operation of a small bending machine becomes a 1 man operation. Further savings are generated when one considers that bending machines can produce any angle of bend between 0° and 180°, whereas trimming of the elbow is required when using fittings if angle of elbow is not the standard 45" or 90°. In many ship installations with tight engine rooms, use of 45° and 90° elbows, without trimming, it not always practical and a great deal of time is wasted in hand trimming elbows.

The use of profile burning machines to eliminate T's, Y's and large elbows (i.e. elbows> 8" dia.) also generates significant savings. One example will be enough to indicate the range of savings. Assume that the 5" X 5" X 5", 90° "T" fitting as shown in Fig. 3 is to be replaced by a profile burnt "T" as shown in Fig. 4. A purchased 5" X 5" X 5" "T" piece currently costs about $55. and has 3 welds and 3 edge preparations that would add another $30. labour charges to

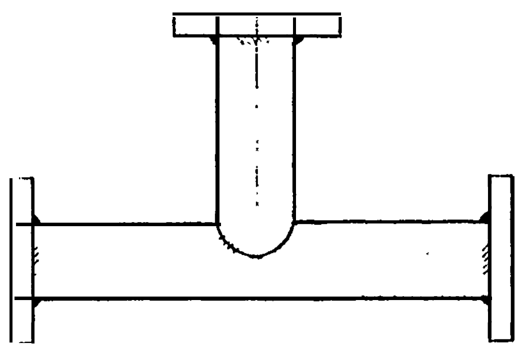
the joint for a total of $85. The profile burnt joint shown in Fig. 4 has 1 end preparation, 1 hole, and 1 weld. It takes about l/2 hour to set up the burning machine for a joint of this type, and about l/4 hour burning time. Manual welding would take a further 3/4 hour for a total labour cost of $11.50. The pipe material in the joint costs $6.25 for a total of $17.75. The ratio of costs "T" fitting: profile cut is approximately 4.78:1. Once again incidental costs have been left out of both calculations.

The "T" piece shown in Fig. 3 is a standard 90°, however optimum conditions for design are not necessarily 90°. The profile burning machine can cut holes and saddles for any angle and also for any combination of pipe sizes.



Joint - using "T" fitting

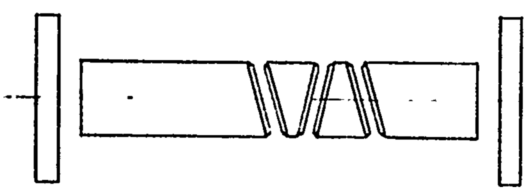
Fig. 3



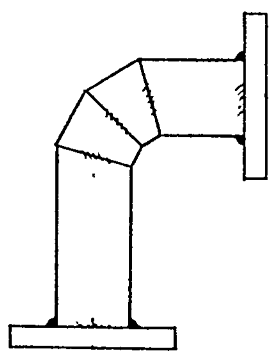
Profile burnt joint

Fig..4

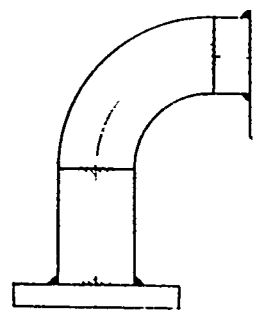
For larger dia. pipes the profile burning machine can also reduce requirements for large elbows. Fig. 5 shows the component parts cut from a straight piece of 16" dia. pipe. Fig. 6 shows the assembled joint. In this case, set-up time on profile burning machine would be l/2 hour, there are 6 cuts which would take another l/2 hour for a total machine operator time of 1 hour or $8.00. The cost of pipe material in the joint would be $38.00. There would be 3 welds in this joint which would cost $57.00 for manual welding. Set-up) time for these 3 welds would be a further $12.00 for a total joint cost of $115.00.



Component parts
Fig. 5

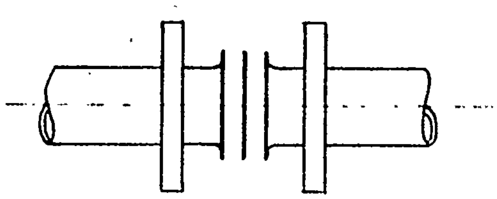


Assembled joint
Fig. 6



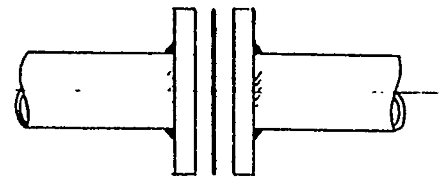
Joint using elbow fitting
Fig. 7

An elbow fitting as shown in fig. 7 would cost about $200. to buy, $8.00 to set up, $38.00 to weld, $8.00 for 2 edge preparations, for a total joint cost of $275.00. The ratio of costs, elbow:prcfile-cut would be approximately 2.39:1. Once again incidental costs have been left out of both calculations.



Joint using loose backing rings

Fig. 8



Welded flanges

Fig. 9

The use of a pipeflanging machine could also introduce considerable saving. Fig. 8 shows a typical vanstone type joint with loose backing rings. Fig. 9 shows the equivalent welded flange joint. The main area of savings lies in the elimination of 2 welded flanges; there is also less material in the flange, and smaller gaskets are used. For a 5" dia. pipe the welding of 2 flanges would take about 84 minutes with manual welding. It is interesting to note the different approach to machine formed flanges in North America and Britain. In North America the approach has been to form a flange in the pipe using a cold spinning process. In Britain the approach has been to hot press the flange. Cold spun flanges as shown in Fig. 8 take about l/2 minute each in the machine. Hot pressed flanges take a little longer - about 2 minutes each.

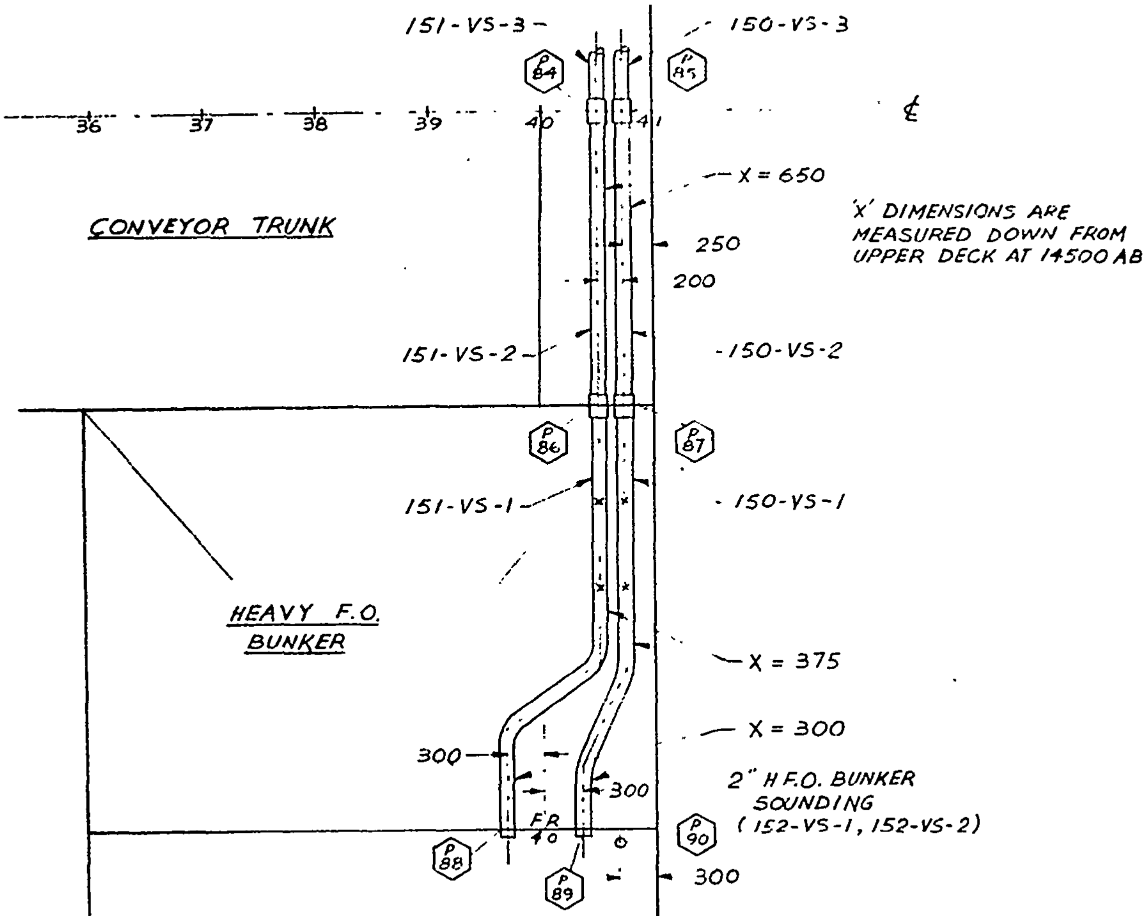
Further advantages of this type of connection lie in the installation on board ship since the backing rings are loose and the bolt holes can be aligned easily. This type

of fitting can be used on bilge and ballast piping, fresh and sea water piping, tank vent piping, and fire and wash-deck piping. It is estimated that on a 30,000 ton bulk carrier, as built in Port Weller, approximately 5000 welded flanges could be replaced by joints of this type.

The material and labour savings accumulated by using pipebenders and profile burners is, in our opinion, sufficient to cover its cost. The production data used by the machine operators could be manually or computer generated. Whatever method is used, however, it is important that the machine operators are not faced with interpreting the data into machine functions. This takes too much time, especially when pipes have a combination of bends and axial rotation or when profile cut pipes require analog settings.

For these reasons the traditional pipe sketches were extended into digitized information for use on pipeshop floor. Fig. 10 shows an extract from a typical pipe system drawing. Fig. 11 shows a typical corresponding pipe sketch for the pipe 151-VS-1. The dimensions of the pipe in relation to the ships baseline, centre line and nearest frame are input into the computer and the digitized information for the bender is output as shown in Fig. 12.

This type of table for use with a pipebender is more or less standard except for the column "minimum bend material".



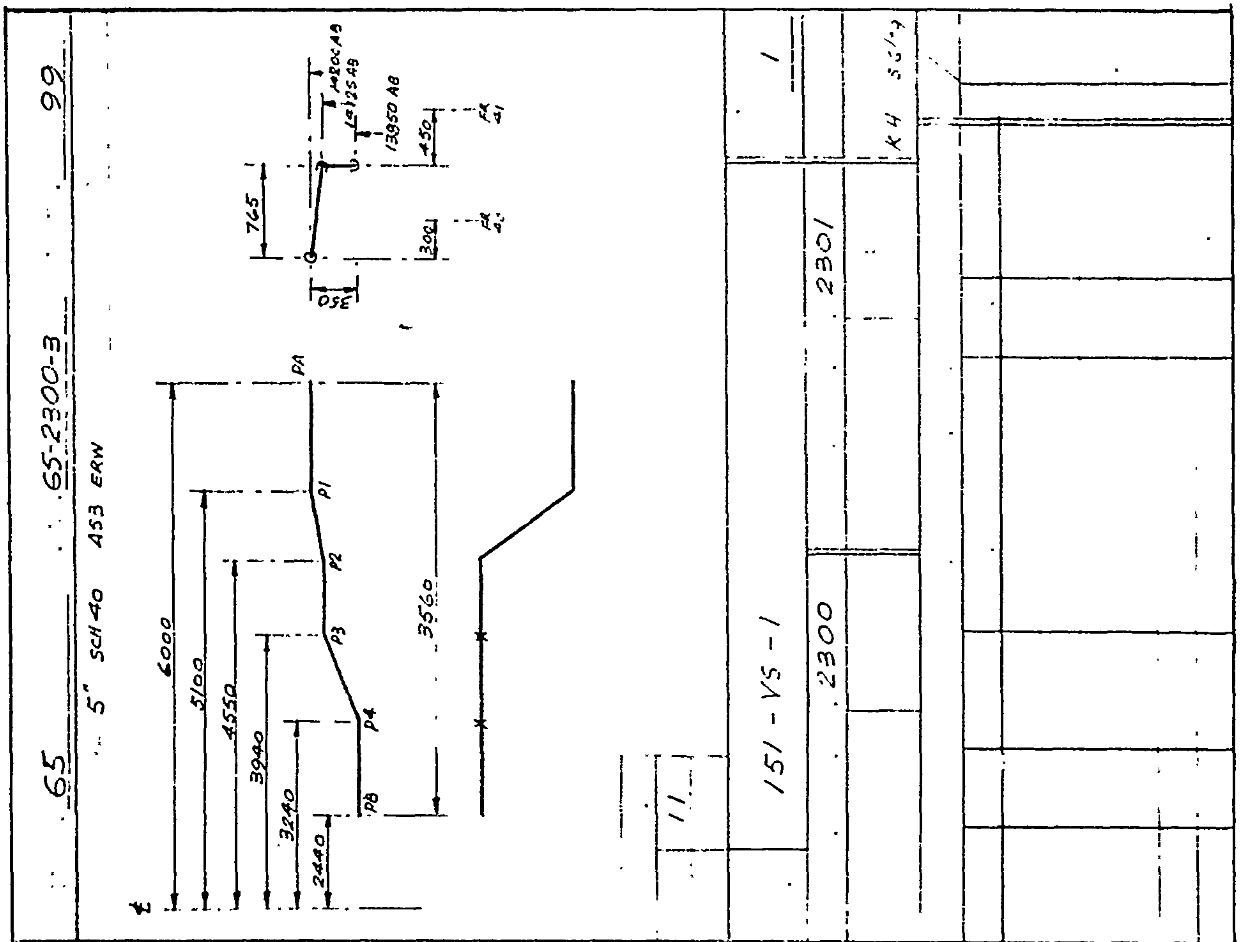
PLAN VIEW AT MAIN DECK
10250 ABOVE BASE

REV	ZONE	ALTERATION	ISSUE

Title : AIR & SOUNDING ARRGT. (I.M.S) (EXTRACT)		DRG. No 65-2300-3
HULL No. 65	A/C# · 2300	Scale 1 : 50
Drawn by · K.H.	Ch'k'd by ·	Date JUN 28,79

PORT WELLER DRY DOCKS
A DIVISION OF UPPER LAKES SHIPPING LTD
P.O. BOX 3011 ST. CATHARINES ONT

FIG 10



PORT WELLER DRY DOCKS

A DIVISION OF UPPER LAKES SHIPPING LTD

P.O. BOX 3011 ST. CATHARINES ONT L2R 7?1

FIG. 11

PORT WELLER DRY DOCKS - PIPE BENDING DETAILS DATE - 08/01/79 TIME - 10:12:51 SHEET 1 OF DWG. NO.65-2300-3

HULL:65 SYSTEM:AIR & SOUNDING FILE:65VS01 ACCOUNT:2300 INTIALS:K.H.

PIPE DETAIL SHEET NO. 1 TO NO.

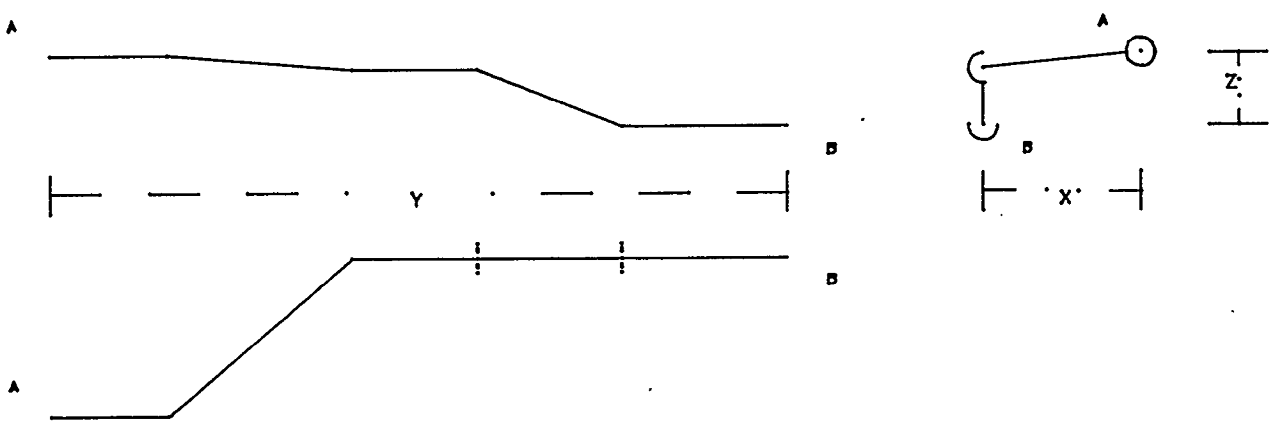
PIPE NO.	SOURCE	SIZE (IN)	SCH	WALL (IN)	TYPE	NO.OF BENDS	END A CUT	LTH.TO TANGENT	ROTATION DIAL SET	BEND ANGLE	MIN.BEND MATERIAL	END B CUT	ORD. BETWEEN ENDS X	Y	Z
151-VS-1	STOCK	5.00	40	.258	A53 ERW	4	SQUARE	769.	0.00	54.42	264.		765	-3560	-350
								684.	180.00	54.42	264.				
								431.	275.60	21.45	104.				
								656.	95.60	21.45	104.				
								752.				SQUARE			

END OF PRINT-OUT
10:13:00 /FINI

FIG. 12

D1 66 AIR SOUNDING(IMS) 65VS01 2300 0 65-2300-3 JD

D2 151-VS-1 4 S 5.00 40 A53 ERW



SCALE 1: 25. looking to STBD

TIME: 10:40:54
DATE: 08/10/79

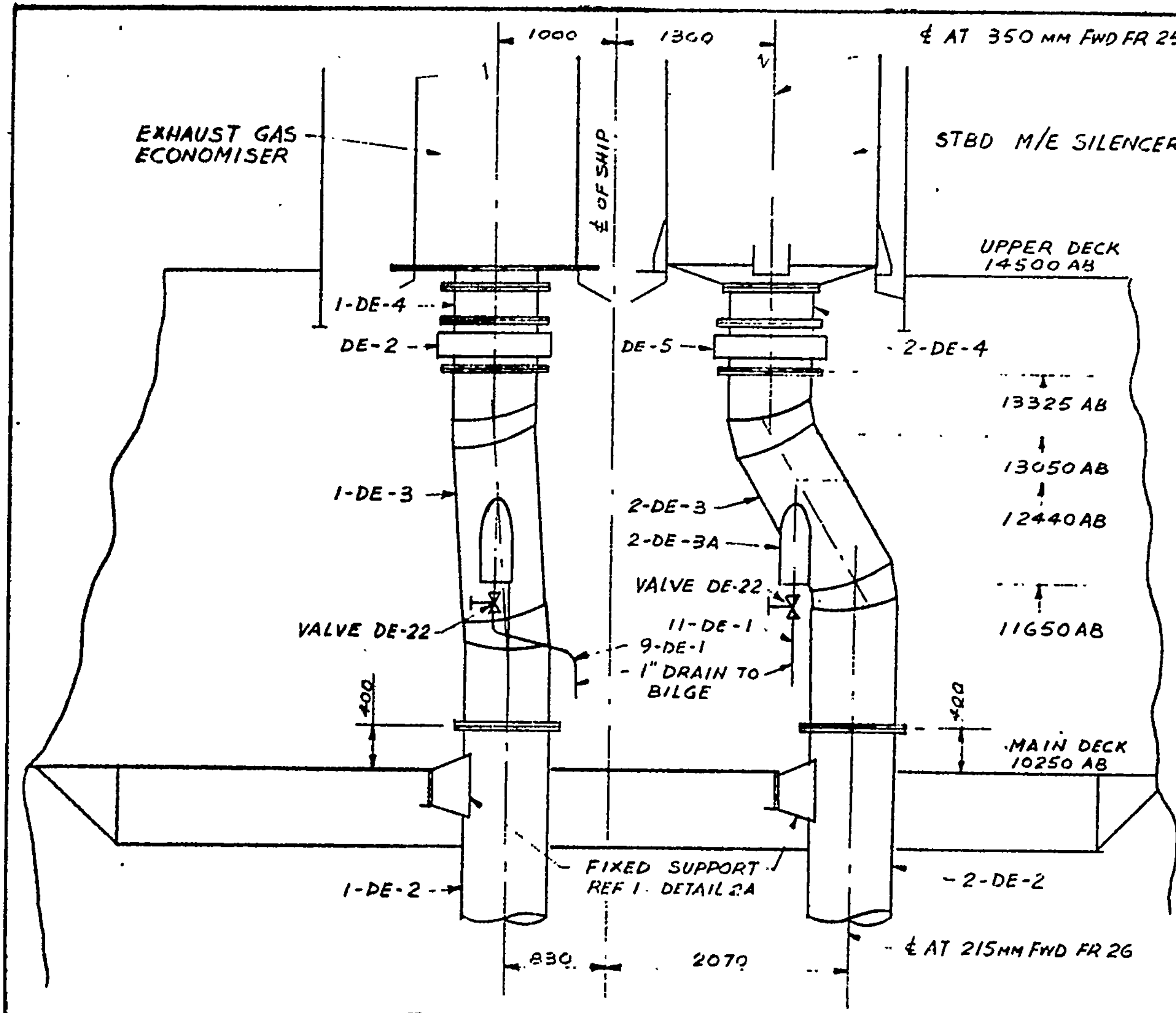
X: 3560. mm
Y: 765. mm
Z: 350. mm

FIG 13

The amount shown in this column is the theoretical minimum amount of pipe that is to be fed into the bend, during the bending operation, to limit the wall-thinning of the outer-bore of the pipe to 14%. This is simply a quality control check dimension measured by a digital read-out display mounted on the bender to indicate that the wall-thinning is within the tolerance.

The same input dimensions used to generate the bending table in Fig. 12 are also fed into a small plotter which draws the pipe sketch as shown in Fig. 13. The work we have done on "plotter produced" pipesketches to date is minimal and has been solely for the purpose of verification of the digitized data used on the shop floor. This verification process is extremely important since a man working' with digitized information on the shop floor is unlikely to recognize incorrect data until he has finished bending the pipe.

For pipes $>$ 8" dia. and $\leq$ 40" dia. we use digitized information for use with a profile burning machine. Fig. 14 shows an extract from a typical arrangement drawing of large diameter exhaust piping. Fig. 15 shows a typical corresponding pipesketch for use on shop floor. Once again the combination of bends, axial rotation, and offset branch lines can take a considerable amount of interpretation on the shop floor. For this reason the dimensions of the pipes are lifted from the



SECTION AT FR 24 LOOKING FORWARD

REV	ZONE	ALTERATION	ISSUE

Title: ARRANGEMENT OF MAIN ENGINE, GENERATOR & BOILER UPTAKE (EXTRACT)		DRG No 65-2420-1
HULL No. 65	A/C# 2420	Scale 1:50
Drawn by K.H.	Ch'k'd by	Date

PORT WELLER DRY DOCKS

FIG 14

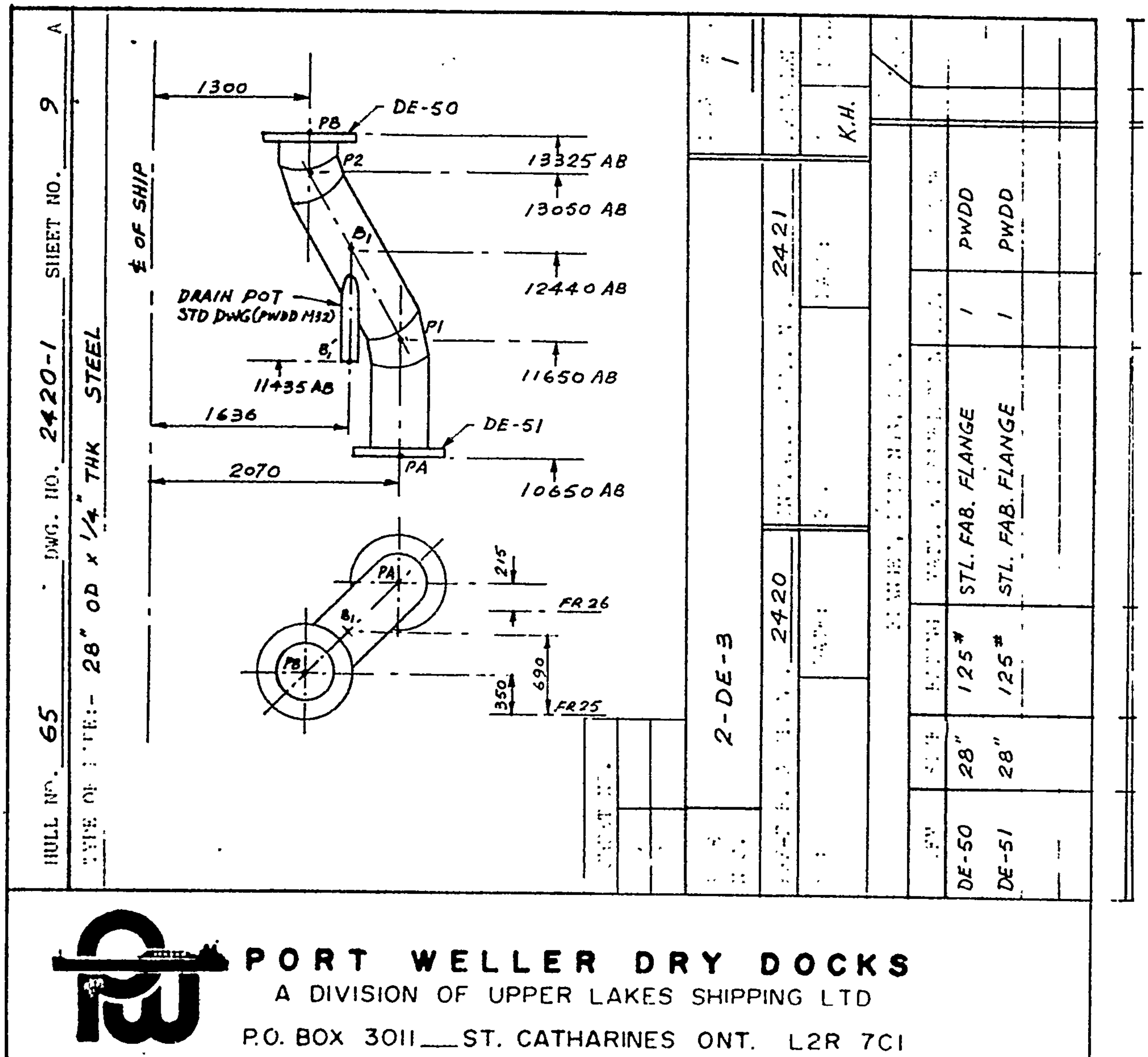

HULL NO. 65
DWG. NO. 2420-1
SHEET NO. 9
28" OD x 1/4" THK STEEL
℄ OF SHIP
1300
DE-50
PB
P2
13325 AB
13050 AB
B1
12440 AB
DRAIN POT
STD DWG (PWDD M32)
B1
P1
11435 AB
11650 AB
1636
DE-51
2070
PA
10650 AB
215
FR 26
690
350
FR 25
K.H.
2421
2420
2-DE-3
PWDD
PWDD
1
1
STL. FAB. FLANGE
STL. FAB. FLANGE
125#
125#
28"
28"
DE-50
DE-51
PORT WELLER DRY DOCKS
A DIVISION OF UPPER LAKES SHIPPING LTD
P.O. BOX 3011 — ST. CATHARINES ONT. L2R 7C1

FIG. 15

PORT WELLER DRY DOCKS - PIPE CUTTING DETAILS   DATE - 08/01/79   TIME - 10:12:15   SHEET 1 OF DWG. NO.65-2420-1

HULL:65   SYSTEM:MAIN ENGINE EXHAUST   FILE:65DE01   ACCOUNT:2420   INITIALS:K.H.

PIPE DETAIL SHEET NO. 9 TO NO.

PIPE NO.	SOURCE	SIZE (IN)	WALL (IN)	TYPE	PC.#	TYPE-OF-CUT	THROAT LENGTH	ROTATION DIAL-SET	BEVEL--SETTINGS HEAD	DIAL	H	ANALOG --- SETTINGS A	B	C	S	SWITCH POSITION D	E	F	X	G
2-DE-3	STOCK	28.00	.250	A53 ERW																
					0/ 1	SLIP-ON	0.	0.0	0.0	0.0	-	-	-	-	-	1	-	3	-	-
					1/ 2	9.5D MITRE	804.	0.0	35.0	90.0	349.	300.0	200.0	58.5	0.0	1	2	4	1	1
					2/ 3	9.5D MITRE	119.	180.0	35.0	270.0	349.	300.0	200.0	58.5	0.0	1	2	4	1	1
						38.0D BCH HOLE	156.	180.0	0.0	0.0	-	227.3	81.3	103.3	0.0	2	1	4	2	1
					3/ 4	9.5D MITRE	1407.	.0	35.0	90.0	349.	300.0	200.0	58.5	0.0	1	2	4	1	1
					4/ 5	9.5D MITRE	119.	180.0	35.0	270.0	349.	300.0	200.0	58.5	0.0	1	2	4	1	1
					5/ 6	SLIP-ON	79.	180.0	0.0	0.0	-	-	-	-	-	1	-	3	-	-
2-DE-3A	STOCK	10.00	.365	A53 ERW																
					0/ 1	38.0D CONTOUR	349.	0.0	52.0	0.0	94.	288.6	103.3	81.3	0.0	1	1	4	2	2
					1/ 2	SQUARE	265.	0.0	0.0	0.0	-	-	-	-	-	1	-	3	-	-

END OF PRINT-OUT
10:12:19 /FINI

FIG. 16

pipe arrangement drawing and input into the computer. The digitized information, as shown in Fig. 16, is the output and consists of pipe identification data, analog settings, and switch positions required to generate each part.

The system described in this paper represents a "first step" towards semi-automatic pipe fabrication in a small shipyard. We recognize that the computer programs are somewhat limited, however it should be noted that all that was required to generate these programs was access to a Fortran Program, a lineprinter, a small plotter, and a small amount of programming time. The programs are small, inexpensive to run, and represent our initial attempts to support semi-automatic pipe production equipment with computer derived production data.

0006

THE AVONDALE PIPE SHOP: HARDWARE AND SOFTWARE STATUS

Harris F. Arnold
Vice-President, Data Processing
Avondale Shipyards Incorporated
New Orleans, Louisiana

Mr. Arnold is Vice-President in charge of Data Processing activities at Avondale Shipyards, Inc. He has 35 years experience with machine accounting, tabulation, and data processing.

The Avondale Pipe Shop - Hardware Status

H. F. Arnold, Vice President -
Data Processing Avondale Shipyards, Inc.

Approximately five (5) years ago Avondale Shipyards in cooperation with the Maritime Administration developed a plan for a semi-automatic pipe fabricating facility.

Our study has been conducted at our main pipe shop and utilized manual fitting, welding and burning as a base along with our original ship layout and flow diagram. We originally had a production capacity of 50 - 55 spool pieces per day with a complement of 76 people in this department. Basic changes which we have accomplished during this study, such as wire-feed welding in lieu of stick welding, provision of cutting station, installation of contour cutting machines and utilization of a limited amount of turning and manipulation equipment has increased our production to 60 - 65 spool pieces per day.

During our investigation we made 42 onsite facility surveys. Nineteen foreign facilities and 23 domestic facilities were visited. We conferred with 26 equipment manufacturers and consultants. We maintained technical liason with 11 foreign and domestic shipyards.

Initially the concept was determined, which established the fundamental equipment requirements necessary for inclusion in a semi-automatic pipe fabrication system. Utilizing the fundamental equipment requirement as a base we proceeded to investigate the design capability of existing equipment manufacturers. During this investigation, we determined that the equipment required would be listed in the three following catagories:

1. Existing
2. Existing, requiring modifications
3. Non-existing requiring the design and manufacture of a prototype.

Upon conclusion of the feasibility study, we entered into a contract with the Maritime Administration.

The primary objective is to design and install a cost effective and semi-automated method of fabricating pipe which will reduce the labor, material handling, storage space and required fabrication area.

Such a facility for the shipbuilding industry must be designed to handle 2" through 24" diameter pipe and all ASTM class and MIL SPEC, and schedules and alloys of pipe used in shipboard systems. The facility must be versatile and equipped to handle repair jobs and specialty items , as well as new vessel piping systems.

The following functions represent a pipe fabrication system which can be implemented along with certified procedures where necessary, , either in part or as an entire system at any major shipyard.

A. A systematic rack storage and locator system for all types of pipe, in sizes for 2" through 24" must be established. The storage racks must provide for loading, selecting and off loading onto a transfer system automatically.

B. A sorting and automatic feed system must be installed at the pipe storage rack so that an operator can automatically select pipe from the rack, load it onto a conveying system and convey it to the work station.

C. The automatic conveying system, for movement of pipe from one work station to another, must be equipped with an automatic unloading device at each station, and a reserve area to hold pipe for each machine.

D. A measuring system must be installed to automatically measure pipe for cutting to length, locating holes and other layout requirements.

E. A system must be furnished to mark each component of the assembly with specific part numbers as identified on the production drawing.

F. Cutting and end preparation machines must be provided. This function is extremely important since, in order to obtain good welding results, the use of machine cutting is an absolute necessity. At this point, all scrap must be conveyed out of the shop area by means of conveyors or other handling equipment.

G. An automatic flange fitting and welding device must be installed and have the capability of processing the pipe alloy mix as well as selecting the flange, orienting. it properly, tacking it and welding both inside and out.

H. Adequate numerically controlled bending equipment must be provided capable of two diameter bending for up to schedule 80 pipe 10 inches in diameter. Adequate bending facilities for larger pipe will depend on the number of ship systems for which larger pipe is required. It can be either hot bending or vibratory bending. An important function of this bending equipment in addition to the two diameter bending of pipe up to 10 inches in diameter is the capability of being automatically fed and bent with flanges installed on both ends.

I. Various types of welding equipment must be selected which will be required to process the mix of pipe through the system. Rolling devices must be provided for the welding of straight pipe and these should incorporate automatic loading and unloading mechanisms as well. The development of semi-automatic welding devices for sub assembly areas is desirable along with certified welding procedures.

J. Assembly areas must be equipped with manipulator fixtures designed so that assembly of pipe sections can be processed in an effective manner. Manipulators are to be fitted with semi-automatic loading and unloading devices, and must be capable of positioning the main body of pipe into position so that fitting and welding can be accomplished. The welding devices should be selected and developed concurrently with the manipulator fixtures for this function.

K. The configuration and quantity of x-ray booths and equipment required to support the maximum work load of this work station and provide handling equipment required for loading, manipulating and unloading the x-ray booths must be determined.

L. A semi-automatic internal and external blasting and coating system for pipe must be provided. A bypass would be included so that all full length pipe which does not require further processing would be channeled directly to the assembly area.

M. A specialty area for fabrication of the enevitable" exception" must be designated. Machines, tools and handling equipment must be selected for processing specialty items of a configuration and volume not suitable for automatic and semi-automatic processing. This specialty area would be accomplished by hand.

N. A final product storage system must be-provided where the fabricated pipe and specialty items can be palletized and stored in a racking system, in usage order, until required. A locator system to be used for accountability and retrieval, should control the storage function.

0. Transportation and handling equipment must be provided for selection load-out and delivery of fabricated pipe to the installation site.

P. The computer software package must be developed to support this fabrication shop. Our investigation has revealed that all manhour savings to be experienced by an automatic system can be completely offset by a major increase in the engineering staff necessary to provide the drawing and other data in a timely manner.

The cost to implement a system as described would require a capital investment of two to five million dollars dependent upon the existing shop facilities and the size, type and volume of the pipe to be processed.

With an investment of this magnitude, management can expect at least 2 things: (1) a return on their investment of approximately 35% per year depending on the facility; and (2) an extremely efficient pipe fabrication shop capable of meeting required production schedules. The system contemplated is designed to produce 150 pipe spools per day, with corresponding limited reduction of skilled shop manpower.

The facility is presently under contruction. We have completed the building extension and raised the floor 6 inches. The automatic racking system, internal/external cleaning and painting systems and the cutting station are scheduled to be installed and operating by late November, 1979. The balance of the equipment is scheduled for installation and checkout by the end of the fourth quarter, 1980.

The majority of the equipment will be originating from Europe coordinated through Oxytechnick of Germany which has been selected as our primary subcontractor responsible for system integration. The N. C. bendin.g machines are supplied by Conrac.

When the facility is completed, it will be the most advanced semi-automatic pipe handling and fabricating facility in the world.

The Avondale Pipe Shop - Software Status

H. F. Arnold, Vice President -
Data Processing Avondale Shipyards, Inc.

The semi-automated pipe shop facility, as mentioned, has been designed to produce 150 pipe spools per day. This increase in production brings with it a similiar, but harder to achieve increase in the daily pipe spool drawing output. In order to keep all the equipment in the pipe shop optimized, it becomes necessary to have a backlog of approximately 300 pipe spool drawings.

Since the existing manual procedures for drawing pipe details could not maintain this backlog, it became necessary to develope an accurate, cost efficient system for the development of pipe detail drawings.

An intense study was conducted in 1977 to determine the best way in which this system could be implemented. The study compared the benefits and limitations of an expanded manual process versus a number of computer assisted approaches. Since the benefits of an automated design far exceeded a manual procedure, we had to decide which automated system best met the needs of Avondale Shipyards.

The system selected by Avondale was CADAM, the computer augmented design and manufacturing system written by Lockheed.

This system was selected based on:

1) The ease with which CADAM could be modified to meet Avondale's pipe drawing requirements.
2) The high function of CADAM which allows for expansion of the graphics system into areas other than piping.
3) The ease with which CADAM could be interfaced to our existing systems and data bases.
4) The ability of CADAM to run on the computer equipment already installed at Avondale.
5) The willingness of Lockheed Corp. to work with us in the overall development of the piping systems and necessary interfaces.

Once the selection of the system was made, we worked very closely with Lockheed in the definition of the project. There were a total of 16 enhancements to the basic CADAM software that we identified at that time as being necessary in the piping system. These enhancements included:

- Full three dimensional capability
- Full rotation of any displayed item.
- The ability to retrieve from a data base and graphically display the symbol for the various pipe fittings needed in a vessel. (Flanges, Valves, etc)
- The ability to add a drawing to the screen by simply indicating a piecemark number.
- The ability to automatically calculate the cut length of pipe and include set back dimensions of pipe in a socket weld or slip on fitting.
- The ability to automatically calculate bends and the angle of two bends in different planes on the same pipe.
- The ability to add a known point by location from the nearest point of reference. (Frames, Water Lines, Etc.)

Work began on these enhancements in the spring of 1978 and by December, 1978, a demonstration of a basic piping system was made. At this point, we were in a position to refine the enhancement requirements and add one or two functional improvements.

One key element in the development of this piping system came in the form of a parts catalog which is a complete file of the geometric and functional information for approximately 10,000 standard pipe fittings, 2" and above, used at Avondale. This catalog, which was developed by Avondale, was designed for easy interface to the enhanced CADAM system and resulted in a simplified piecemark numbering system for the yard.

With this catalog, the piping engineer can page through the catalog index, select the appropriate piecemark and have it displayed on his graphics device at whatever coordinates he selects. This procedure is repeated until all the piecemarks are selected and displayed and the pipe drawing is complete.

At that time, or whenever it is necessary to plot the pipe drawing, the catalog will supply all the pertinent information for each piecemark identified. This can include any special information needed by the pipe shop in the fabrication of that pipe spool such as special weld considerations or critical dimension data.

The combination of this parts catalog and CADAM with its modifications is estimated to increase our pipe detail drawing productivity by no less than 5 to 1.

Another feature designed into the Avondale pipe spool drawing system is a table of limitations for the equipment in the pipe shop. Every completed PD will be edited against this table to determine if the PD can, in fact, be fabricated in our facility. Those drawings that fail the edit will be flagged for correction by the engineer who created it thereby eliminating the possibility that a pipe spool can begin through the pipe shop and then be scrapped because it is impossible to produce.

The link that ties the pipe spool drawing function to the semi-automatic pipe shop is the scheduling/routing system that is now in its design stage.

This system will take all of the PD'S that are completed and released, prioritize them based on the elements of the specific job, analyze the functions needed to be performed in the pipe shop, determine the specific machines needed to fabricate each PD, schedule the PD'S, route them through the pipe shop to optimize the equipment and generate a two-weeks workload for the pipe shop complete with a list of materials required at each location throughout the shop.

Other considerations in this scheduling/routing system are the inventories of pipe and fittings, and the on order status of pipe and fittings, the equipment maintenance schedules, equipment outage information, alternate routing data, manpower scheduling data and work in process information.

With this system we have bridged the gap between engineering and manufacturing with significant productivity gains.

We expect to have all the enhancements to CADAM completed and in production by the end of 1979. We also expect to have the scheduling software in place by the time the semi-automated pipe shop is in production. At that time we anticipate using the CADAM system for other engineering and production requirements.

A PROGRESS REPORT ON THE CNC SHIP FRAME BENDER

Donald W. Wall
Project Manager
National Steel and Shipbuilding Company
San Diego, California

Mr. Wall is Project Manager for the CNC frame bender at the National Steel and Shipbuilding Company. He has a degree in mechanical engineering, and is currently pursuing a masters degree in business administration. His previous experience includes steel mill maintenance supervision, air pollution research and equipment design.

Filippo Cali
President
Cali and Associates Incorporated
New Orleans, Louisiana

Since the founding of Cali and Associates Inc, Mr. Cali has directed the continuous development of the SPADES system, and expanded the company to provide complete N/C lofting services to the shipbuilding industry, with particular emphasis to the small and medium size shipyards. He has an engineering degree from the Italian Naval Academy.

Mr. Cali has over 30 years experience in all phases of shipbuilding. Prior to founding Cali and Associates, Mr. Cali held the positions of Vice-President for Engineering at Avondale Shipyards, and Director of Engineering at Litton Ship Systems.

The U.S. Navy and National Steel and Shipbuilding Company in San Diego are cooperating to build and test a new and more efficient machine for forming ship's frames. The device is a CNC Ship's Frame Bender. The frame bender is a hydraulically powered, computer controlled machine which will cold form typical angle and "Tee" shapes used in the hulls of ships.

There are several unique features of this machine. It will eliminate labor and energy intensive hot forming processes now in use. The computer control features "adaptive feeback" which will automatically compensate for variations in the properties of a beam being formed. The desired curvature of the beam will be "read in" via a paper tape supplied by an existing computer at NASSC0. The need for templates and human judgement will be eliminated by the computer. The bender will form beams by developing a pure bending moment rather than *a* combination of moment and shear, within the work section of the beam.

The frame bender concept, and a working model, were developed at Case Western Reserve University by Dr. H. W. Mergler. The U.S. Navy's Manufacturing Technology division and NASSCO are funding the construction, installation and testing of a prototype capable of handling beams up to 8" flange by 25".web and 42 feet in length. Construction was begun in late 1978 with all parts delivered to San Diego in July of this year. Installation is presently underway working toward a demonstration date later this year.

The frame bender shapes a beam by progressively forming short sections as the beam is fed through the bender. A Work section of 14 to 48 inches in length is clamped at each end by the fixed head and the moving head. A pure bending, moment is then exerted on the work section by rotating the moving head in a horizontal plane relatively to the fixed head. The forces applied and resulting deformation are monitored by various transducers which feed information back to the computer. After making a bend the beam is allowed to spring back. The curvature is then compared to the desired curvature by the computer. If the bend is not within tolerances the same section is rebent using the results of the previous bend to recalculate the properties of the section. Once the bend is within tolerances the beam is advanced through the heads to the next work section and the process is repeated.

The frame bender is presently being assembled and installed in the Plate Shop at NASSCO in San Diego. All of the major components have been set in place on special footings and electrical and hydraulic installation is being performed; Assembly is scheduled for completion late September, 1979 with shakedown and "debugging" to be complete by late October.

After the demonstration date additional support equipment will be fabricated and installed to bring the machine into full production. An automated system is being developed to transfer beams directly from the beam welder to hold tables at the entry end of the Frame Bender. Each beam will then be hoisted to a feed in table by a remotely controlled "picker" on a dedicated semi-gantry crane. The feed in table will be capable of handling--all cross sections and lengths of beams. It will grasp the end of the beam, raise and properly orient the beam then charge it into both heads of the Frame Bender; All this will be; controlled remotely from the operator's platform allowing full visibility of all operations. After a beam has been formed it will be extracted from the bender by the picker and crane while another beam is being charged into the bender. Finished beams will be stacked downstream of the bender for later distribution.

All of this support equipment is scheduled to be in operation in early 1980. At that point the CNC ship's Frame Bender will be fully integrated into the production line at NASSCO and will be helping to reduce costs and conserve energy in the production of ships.

PART II - SOFTWARE AND DOCUMENTATION

BY FILIPPO CALI, PRESIDENT, CAL1 AND ASSOCIATES, INC.

This part of the paper has been written with two goals in mind:

1. Report on the state of developement of Host Software;
2. Provide a preliminary documentation for the system programmer to be able to link the software with any system other than "SPADES".

It is appropriate at this point to give Mr. K. W. Cheng of Cali and Associates, most of the credit for the development of the "Host" Software described in this paper.

STATE OF SOFTWARE DEVELOPMENT

The basic design criteria for the Host Software were described in the 1978 SNAME Paper, "Development and Application of a Computer-Controlled Ship's Framebender in the Automated Shipyard," to which the reader is referred.

These criteria have essentially remained unchanged and the development was done accordingly. The software is, at the present time, ready and paper tapes can be generated directly from the ship's geometry definition as it exists in the "SPADES" Database.

The portion of the program dealing with the computation of the length of the work sections was the most difficult in view of the conflicting requirements.

- The geometry of the beam requires certain work lengths to better approximate the desired curvature
- Efficiency of operation (i. e. minimum cycle time) requires the longest work length allowable by the Framebender
- Use of the stabilizers and the operational requirement of not wanting to change the number of stabilizers during the bending of a beam dictate a minimum work length

These often conflicting requirements have been taken into account, but provisions have been made to easily bypass one of them or change the priority, based on the feedback of the forthcoming tests. It is my opinion, for instance, that total elimination of the use of the stabilizers in conjunction with appropriate selection of work lengths will result in a better overall cycle time.

The portion of the software dealing with checking beam geometry with physical machine parameters has been left incomplete pending determination of these parameters after installation.

The bender is now in the final phase of installation and testing will soon commence. We all expect that a certain amount of tuning of Host Software, Mini-Computer Software and Bender itself will be required. The area requiring the most tuning will be measuring of the vertical (in the Z-X plane) bending, existing in the beam being processed in order to eliminate it and for the purpose of refining the out-of-plane compensation ratio.

In order to achieve the required capability to link it with any N/C Lofting system other than "SPADES", the software has been organized in two FORTRAN SUBROUTINE CALLS. A separate driver program that reads manual type input data and calls these two subroutines has also been provided for those potential users who do not use any data base for N/C lofting. (See Fig. II-l)

The First Subroutine Call is:

CALL FRBNDR (Argument List)

This subroutine receives through the argument list the lofted contour of the neutral axis of the beam and the necessary physical and geometrical characteristics of the beam.

After operating on the above data to create the numerical model required by the framebender, the subroutine returns, through one of the arguments, an array to be used in the subroutine call:

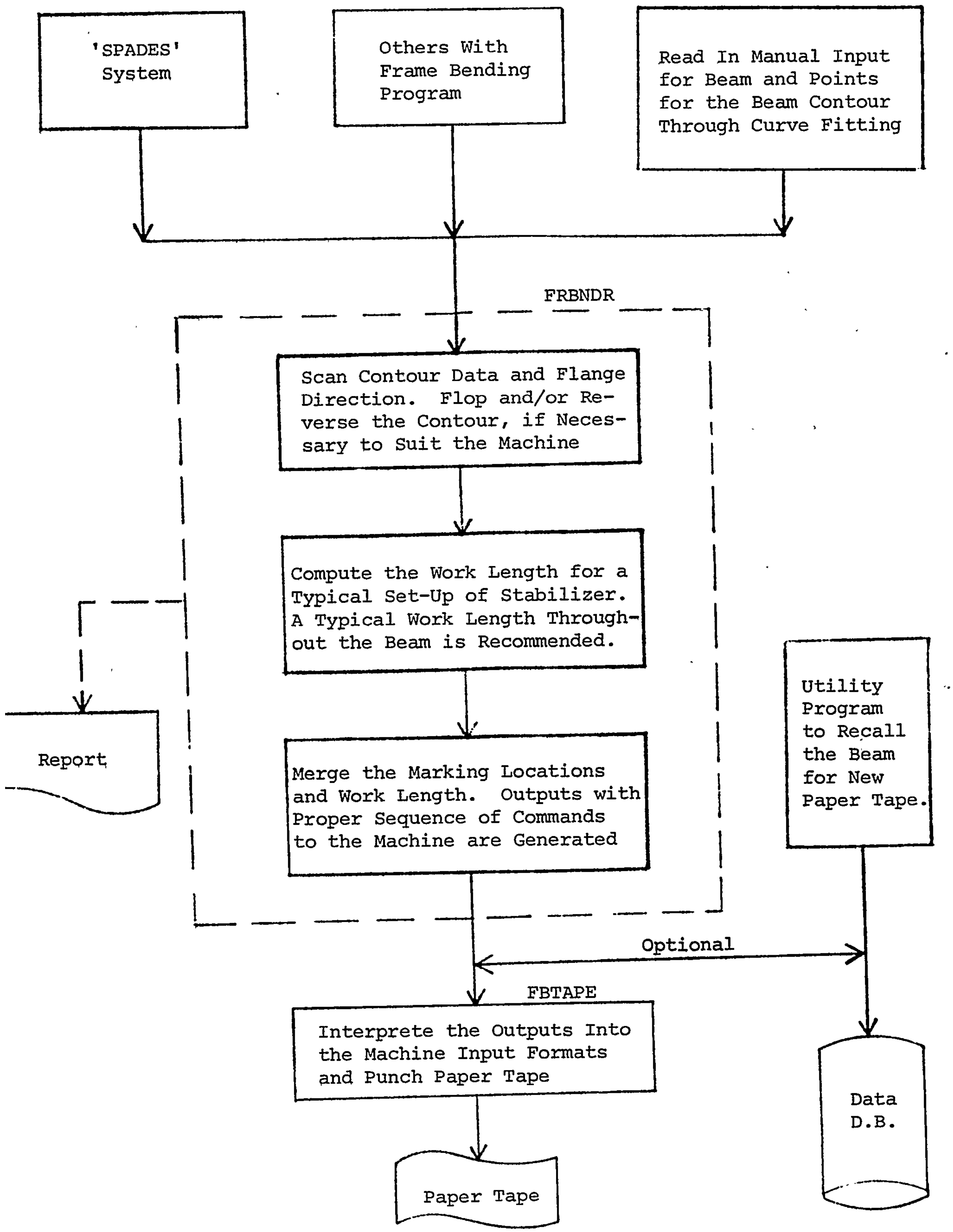
CALL FBTAPE (Argument List)

Subroutine 'FBTAPE' translates the array generated by 'FRBNDR' into the paper tape image required by the framebender's controller.

The software was set up on purpose with these two calls so that a user that wishes to store the array generated by 'FRBNDR' in a database can do so and have a utility program to recall the array and regenerate the paper tape image for punching or 'DNC' without calling 'FRBNDR'

For further details on the use of these two subroutines, see the following 'Preliminary Software Documentation".

FIG. II - 1



'SPADES' System
Others With Frame Bending Program
Read In Manual Input for Beam and Points for the Beam Contour Through Curve Fitting
FRBNDR
Scan Contour Data and Flange Direction. Flop and/or Reverse the Contour, if Necessary to Suit the Machine
Compute the Work Length for a Typical Set-Up of Stabilizer. A Typical Work Length Throughout the Beam is Recommended.
Report
Utility Program to Recall the Beam for New Paper Tape.
Merge the Marking Locations and Work Length. Outputs with Proper Sequence of Commands to the Machine are Generated
Optional
FBTAPE
Interprete the Outputs Into the Machine Input Formats and Punch Paper Tape
Data D.B.
Paper Tape

Linkage Procedure With a Lofting "N/C System"

In order to properly link the software, the following must be done:

A - Initialization (for the entire program)
The initialization procedure must contain the FORTRAN statement:

```
CALL FBSTCM
```

A common must be included and initialized as follows:

```
CoMMON/MISCS/IUNIT(6), NERR(4), TOLER(25), IDTR(6)

IUNIT(1) = FORTRAN UNIT FOR PRINTER FILE
IUNIT(3) = FORTRAN UNIT FOR PAPER TAPE IMAGE FILE
```

The remaining variables in the common are initialized by the call to 'FBSTCM'

B - Initialization for Each Beam
The variables array 'NERR' in COMMON/MISCS/ must be re-initialized as follows:

```
NERR(l) = 0
NERR(2) = 0
NERR(3) = User ID for associating diagnostic error messages
NERR(4) = 0 When set to greater than 0, it triggers a trace printout
```

Two additional commons require re-initialization for each beam.

```
COMMON/SHAPE/ NSHAP, KTEXT(lO), ITYS, SEMB(24)
```

Prior to the call to 'FRBNDR' the following variables in the common must be initialized as follows:

NSHAP	SHPAE NO. (INTEGER 501-1499)
KTEXT(7-10)	ALPHABETIC DESCRIPTION OF SHAPE
ITYS	TYPE OF SHAPE 1 - Flat Bar 2 - Angle Bar 3 - T-Beam 4 - Bulb Angle 5 - Not applicable 6 - Not applicable 7 - NASSCO special built-up angle bar

SEMB(1)	Area of cross section in IN2
SEMB(2)	Weight per Foot in LBS
SEMB(3)	Web depth in Feet
SEMB(4)	Flange width in Feet
SEMB(5)	Web thickness in Feet
SEMB(6)	Flange thickness in Feet
SEMB(7)	Moment of Inertia about major axis in IN^4
SEMB(8)	Section of modules in IN^3
SEMB(9)	Not used in this program
SEMB(10)	Distance from centroid to flange (Feet)
SEMB(11)	Moment of Inertia about minor axis in IN^4
SEMB (12)	Section of modules in IN^3
SEMB(l3)	Not used in #is program
SEMB(14)	Distance from centroid to web if X-section of beam is not symmetrical (Feet)
SEMB(l5)	Tangent of separation angle
SEMB(l6)	Not used in this program
SEMB(17)	Not used in this program
SEMB(l8)	Amount of recess (NASSCO special built-up type) (Feet)
SEMB(19)	Material code (Integer O-9)
SEMB(20)	Young's module lbs/in^2
SEMB(21)	Yield stress lbs/in^2
SEMB(22)	Density of material lbs/ft^3 (used when unit weight is not given)
SEMB(23-24)	Not used in this program

The program will compute the data in SEMB(7) through SEMB(17) if SEMB(7) is set to zero.

The data in SEMB(1) and SEMB(2) will be calculated if they are set to zero.

The data in SEMB(l9) through SEMB(22) will be set to the default values for mild steel.

SEMB(19)	= 0
SEMB (20)	= 30 x lo^6 LBS/IN^2
SEMB(21)	= 35,000 LBS/IN^2
SEMB(22)	= 490 $\#/Ft^3$

COMMON/TEMP/IDN, ITYPE, ITEXT(26), OPEN(l0)

Some of the variables in this common are set by the calls to 'FBSTCM' and 'FRBNDR'. The following variables should, however, be set by the calling program.

IDN — An integer value representing the assigned identification number of the paper tape within any one ship (JOB).
The value is a seven digits number with the format TPPNNNNN where:

T = 4 For a paper tape to bend or straighten specific beam in the ship
= 5 For straightening a stock beam

Paper tapes for straightening stock beams (T=5) are recognized as such by the mini-computer in the framebender and no error is given when the end of the beam is detected by the limit switch on the feed side of the machine, since stock lengths can vary. The mini-computer allows also the storing in core of a number of these tapes for easy recall by the operator.

PPNNNN — = Arbitrary six digits number. Within the "SPADES" system, PPNNNN is controlled by the system.

ITEXT(1) — Integer value of Julian Date (YYDDD)

ITEXT(3)* — Integer value of time of day (HHMMSSS) where:

HH = Hour (O-23)
MM = Minutes
sss = Tenths of seconds

ITEXT(5) — Ship (Job) ID number (integer 1 to 99)

ITEXT(6) — Rev. number of tape (integer 1 to 99)

ITEXT(7)* Ship name (A4 Format)

ITEXT(8-9)* Ship account (2A4 Format)

ITEXT(11-14)* Piece mark (T=4) or stock number (T=5) (4A4 Format)

*Note: Setting of these variables is recommended but not mandatory.

OPEN(l) Real number of format MOSSSS.0 where:

M = Material ID (O-9)
ssss = Beam ID (501 to 1499)

OPEN(2) Minimum required cut length of beam (internal units)

OPEN(5) Total weight of beam

OPEN(6-8) Three dimensional center of gravity of the beam in the ship

These values in ARRAY 'OPEN' are also optional. Within the "SPADES" system they are set to 1000000.0 when not used as in the case of a tape for straightening a stock beam.

c - <u>Call of subroutine 'FRBNDR'</u>

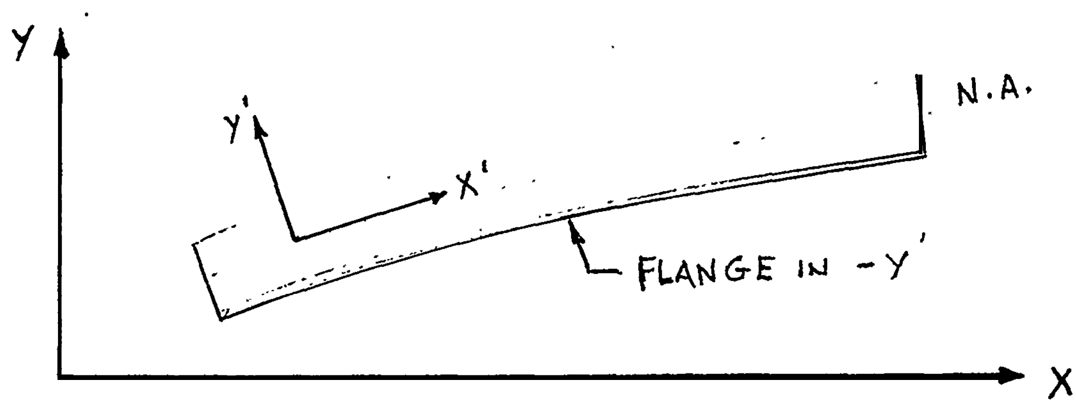
CALL FRBNDR (IOP, IDS, FBCNR, NCFB, FBXY, NAMREF, IRRAY)

<u>INPUT ARGUMENTS</u>:

IOP Operation Control Word
= 1 Bend Beam
= 2 Straighten Beam

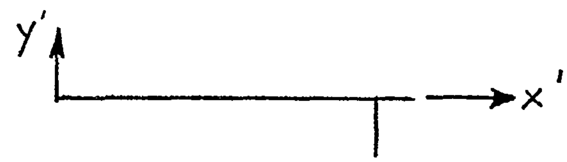
IDS(7) Control Words

IDS(l) Flange Location Relative to the COntOUr
= +1 Flange in positive y' of contour
= -1 Flange in negative y' of COntOUr



IDS(2) Flange Orientation for Unsymmetrical Shape
= +l Flange in positive y' direction

= -1 Flange in negative y' direction



IDS(3) Total no. of segments of contour (INA)

IDs(4) Total no. of marks on the beam (INM)

IDS(5) Index of mark array for fwd. end cut template ref. mark

IDS(6) Index of mark array for aft end cut template ref. mark

IDS(7) Total no. of words in IRRAY at return (NWD)

FBCNR(4,INA) Contour geometry at N. A. in absolute coordinates in 'ESSI' format

1 - X-coord. of starting point
2 - Y-coord. of starting point
3 - X-coord, of center
4 - Y-coord. of center

NCFB(INA) Indicator of 'ESSI' segment

0 - Straight line
1 - Positive rotation
2 - Negative rotation

Note: FBCNR (1,INA) and FBCNR(2,INA) contain the end point of segment (INA-l), i.e. the contour is defined by 'INA-1' segments.

FBXY(2,INM) Marking location on N. A. contour sorted in sequence along the contour

1 - X Abs.
2 - Y Abs.

NAMREF(3,INM) Names of marks

OUTPUT' (return) ARGUMENTS:

IRRAY(NWD)	"FRBNDR" returns in this array the data required for calling 'FBTApE'. The array size (NWD) provided by the calling program should be 500 words.
IDS(7)	The contents of this variable in the input argument 'IDS' is set up to the actual no. of words used in ARRAY 'IRRAY'. The calling program should check this value for not equal to zero. A zero value indicates an error condition.

D - Call of Subroutine 'FBTAPE'

CALL FBTAPE (IRRAY)

INPUT ARGUMENT:

IRRAY	The ARRAY generated by 'FRBNDR'

Upon return from "FBTAPE" the variable OPEN(4) should be checked for the following values:

OPEN(4)	0 Paper tape image generated without errors
	8 System logic error - No P/T
	9 User errors ocurred. Paper tape should not be used in the framebender.

The identification number assigned to the paper tape will be as follows:

JJNNNNTPP-RR where:

JJ	= Value assigned to ITEXT(5)
NNNNTPP	= As defined in "IDN"
RR	= Rev. no. as assigned to ITEXT(6)

In order to avoid duplication of names of both subroutines and commons between the calling program and the software a list of the names used is included.

LIST OF COMMON AND SUBROUTINE NAMES USED

The following names have been used in the software and therefore cannot be duplicated within the calling program.

NAMES OF SUBROUTINES

ABTOIN	FRBOUT	OPDRTN
AFORMT	FTTOHD	OUTAPE
ARCLNG	GETBYT	PACK
AXES	GLRMRK	PRINTP
BPCALC	GRPNT	PRTERR
CHKPRT	GRSEG	PRTVAL
CIRCEL	IEBCDC	SEARCH
CIRCFT	IGERR	SETCTL
COSCAN	INTFRC	SLOPEA
CURVES	INTOAB	SNCS
PATE	ISGATN	STBREQ
ERR1	ITOALF	STPC
FBCHR	IVSRAY	STOBYT
FBFEED	JASCII	SPDVAL
FBLABL	MORAY	SWAP
FBSTCM	NCFBIN	UNPKD
FBTAPE	NCFRPT	WINDW
FRBNDR	COMTIM	WTCALC
FRBNIT		ZFORMT

NAMES OF COMMONS

/ALFBET/	/FBNDCT/
/BLTKNT/	/IGERR1/
/CNVRTl/	/LPRP1/
/CNVRT2/	/MISCS/
/DELET1/	/MISCS2/
/ESSEIA/	/FOSTBF/
/FBWORK/	/TEMP/
	/SHAPE/

STAND ALONE PROGRAM FOR MANUAL INPUT

As mentioned earlier this program was conceived to give the user, who does not have a databased oriented N/C Lofting capability, a relatively easy way to generate paper tapes for the N/F Framebender.

The type of input data needed can be divided as follows:

- DESIRED BENDING
  This can be given by the use of a discrete number of points along the desired curvature or by a series of straight line and circular segments.

  If points are used the "SPADES" curve fitting routine is used to generate the contour. Flags to indicate tangency conditions and change of curvature are allowed. In either of the above cases the given data can be for the neutral axis or for the trace of the beam.

- DESIRED MARKING
  This is indicated by giving a series of points, where marking is desired, in the same coordinate system used to define the bending.

- PHYSICAL PROPERTIES OF BEAM
  This type of data describes the cross-section of the beam. The material is assumed to be mild steel if not otherwise specified.

- ADMINISTRATIVE DATA
  This includes the desired tape no. and rev. The piece mark of the beam or the stock no. of the beam in the case of a tape for straightening.

When this program is used to generate the standard tapes for straightening stock beams, there is no need to provide any bending and marking data. The only data needed is the properties of the beam, the number of the beam (501 to 1499), the stock number, and tape revision. The tape number is assigned by the program.

Within the "SPADES" environment only the beam number and stock number are needed, with everything else provided from the database,

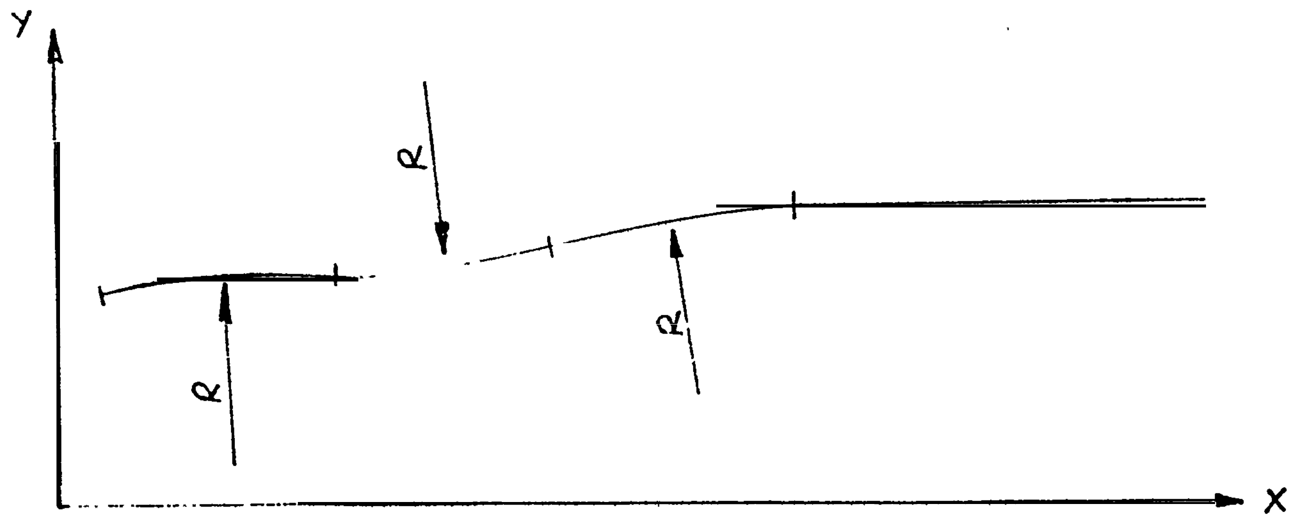
A user manual is being prepared giving detailed instruction on the format of the input data required in each case.

Figs. (II-2) through (II-10) have been included for general information.

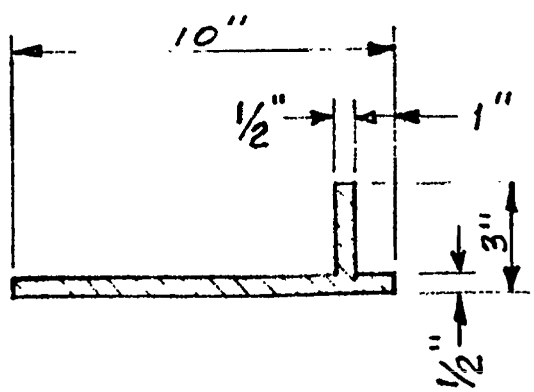
```
JOBD CTUG        .                      21                          300000
BEAM WEB FRM. 49                   4023201              1
SHAP BUILT-UP L 10X4                   521              7  I   1.
PRTY                          I   10.         I   4.       I       .5   I    .5
PRTY                                            22.95
CNAX                                6.261       7.364
                                    7.246       7.458
                                    8.385       7.549
                                    9.567       7.637
                                   10.795       7.737
                                   12.153       7.874
                                   13.887       8.108
                                   15.429       8.378
                                   16.542       8.599
                                   17.575       8.811
                                   18.604       9.011
                                   19.770       9.211
                                   21.045       9.380
                                   22.123       9.471
                                   23.048       9.500
                                   40.000       9.500
M/RK J     F0   P                   9.000       7.595
     S     12   P                  12.000       7.857
     J     E0   P                  18.333       8.959
     D     F14  P                  19.500       9.167
     D     F27  P                  27.500       9.500
     J     F0   P                  28.000       9.500
     S     33   P                  33.000       9.500
     J     G0   P                  35.833       9.500
     D     MD2  P                  39.000       9.500
     J     H0   P                  39.281       9.500
ENDS
```

SAMPLE OF INPUT FOR BENDING

FIG. II - 2



SKETCH OF CURVATURE AT THE NEUTRAL AXIS FOR SAMPLE BENDING FRAME



CROSS SECTION OF THE BEAM USED IN THE SAMPLE INPUT

FIG. II - 3

NUMERICAL CONTROL FRAME BENDING PROGRAM MANUAL INPUT

JOB NAME CIUG
JOB ID. 21
DATE 09/04/79

PHYSICAL PROPERTIES OF BEAM

BEAM NO. 521
BEAM TYPE
AREA OF CROSS SECTION 0.00
WEIGHT PER FOOT 22.95

WEB DEPTH 10.00
FLANGE WIDTH 4.00
WEB THICKNESS 0.50
FLANGE THKNESS 0.50
AMOUNT OF RECESS 1.00
NASSCO BUILT TYPE

COORDINATES OF CONTOUR IN ESSI FORMAL. NO. OF SEGMENTS = 13

1	6.261	7.364	12.578	-52.343	2
2	8.634	7.568	43.398	-441.294	2
3	10.136	7.681	1.936	105.807	1
4	11.747	7.829	6.306	58.077	1
5	13.760	8.388	7.942	46.684	1
6	15.597	8.410	2.973	74.799	1
7	17.113	8.717	75.405	-280.154	2
8	18.328	8.959	29.360	-49.984	2
9	19.796	9.015	24.413	-21.380	2
10	21.555	9.429	23.392	-12.765	2
11	22.830	9.498	23.053	-4.769	2
12	23.048	9.500	23.048	9.500	0
13	40.000	9.500	0.000	0.000	0

NAME AND COORDINATES OF REF. MARKING POINT
NO. OF POINTS = 10 FWD AND AFT TEMPL. POINTS 0 0

1	J	DO	P	9.000	7.555
2	S	12	P	12.000	7.857
3	J	EO	P	18.333	8.959
4	D	F19	P	19.500	9.167
5	D	F27	P	27.500	9.500
6	J	FO	P	28.000	9.500
7	S	33	P	33.000	9.500
8	J	GO	P	35.833	9.500
9	D	MD2	P	39.000	9.500
10	J	HO	P	39.281	9.500

PRINTOUT OF DATA USED BY THE PROGRAM
(Bending Tape)

FIG. II - 4

DATA FOR EACH WORK LENGTH

NO.	LENGTH	RADIUS	BENDING	TARGET	WEIGHT	AT CYL.
1	2.077	-77.284	33.461	-1.041	1861.246	526.795
2	0.978	-391.278	31.396	-0.530	2903.759	495.838
3	4.000	48.007	30.391	-0.756	940.586	396.159
4	2.353	46.802	26.252	-2.877	1136.222	336.915
5	0.707	67.453	23.758	-3.923	1789.520	311.986
6	2.728	-50.311	22.768	-3.867	848.816	258.178
7	3.268	-22.460	20.229	-2.637	636.780	194.527
8	4.030	5058.271	17.143	-0.033	465.664	126.784
9	4.030	$1000000.0	13.114	-0.033	360.832	70.457
10	4.030	$1000000.0	9.084	-0.033	275.455	26.255
11	4.030	$1000000.0	5.054	-0.033	48.501	0.000

GIRTH LENGTH OF MARKING POSITION

1	2.749
2	5.760
3	12.191
4	13.377
5	21.396
6	21.856
7	26.896
8	29.723
9	32.896
10	33.177

PRINTOUT OF NUMERICAL MODEL FOR THE FRAMEBENDER

(Bending Tape)

FIG. II - 5

```
S...
21320140020
L3
TAPE 2183201-402
REV  NO        1
DATE     09/04/79
JOB
DB JOB       CTUG
WEB FRM. 49
L4
$
TAPE NO. 21-3201-402-01
BEAM ID  521     BUILT-UP L 10X4
BEAM LENGTH REQ. 33-10-12/16
PC. ID. WEB FRM. 49
 1 STABILIZERS REQ.     SPACED BY
  26-1/2
BEAM FLG. DOWN
USE S. CLAMP
$
S145,759
R177
H1
MF
M0
M1
F1822
M2
F3400
M2
P1181
M4
F614
P4800
W49,0
X+6065Y-38
F4836
P4800
W275,26
X+10901Y-38
F551
M2
F600
M2
F3685
P4800
W361,70
X+15736Y-38
F4836
P4800
```

PRINTOUT OF PAPER TAPE CONTENTS FOR BENDING

FIG. II - 6

```
JOBD ****            STNG            0
BEAM STOCK S-2079                                  1
SHAP BUILT-UP ANGLE              501          .    7 I   1.
PRTY                         I  10.      I    5.     I   .5      I  .50
PRTY1                          3.75         24.67     35000.    ,  30.
ENDB
```

SAMPLE OF INPUT FOR STRAIGHTENING

FIG. II - 7

```
NUMERICAL CONTROL FRAME BENDING PROGRAM MANUAL INPUT

JOB NAME  ****
JOB ID.      0
DATE       0./00/00


PHYSICAL PROPERTIES OF BEAM

BEAM NO.   501
BEAM TYPE      7
AREA OF CROSS SECTION    3.75
WEIGHT PER FOOT   24.67

WEB DEPTH          10.00
FLANGE WIDTH        3.00
WEB THICKNESS       0.50
FLANGE THKNESS      0.50
AMOUNT OF RECESS     1.00
NASSCO BUILT TYPE

COORDINATES OF CONTOUR IN ESSI FORMAT.  NO. OF SEGMENTS =    2

   1    0.000    0.000    0.000    0.000   0
   2   60.000    0.000    0.000    0.000   0
```

PRINTOUT OF DATA USED BY THE PROGRAM
(Straightening Tape)

FIG. II - 8

DATA FOR EACH WORK LENGTH

NO.	LENGTH	RADIUS	BENDING	TARGET	WEIGHT	AT CYL.
1	4.000	0.000	61.333	-0.104	3109.597	1617.375
2	4.000	0.000	57.333	-0.104	2767.471	1418.778
3	4.000	0.000	53.333	-0.104	2446.125	1232.914
4	4.000	0.000	49.333	-0.104	2145.563	1059.783
5	4.000	0.000	45.333	-0.104	1865.784	899.385
6	4.000	0.000	41.333	-0.104	1606.789	751.720
7	4.000	0.000	37.333	-0.104	1368.575	616.789
8	4.000	0.000	33.333	-0.104	1151.151	494.590
9	4.000	0.000	29.333	-0.104	954.511	385.126
10	4.000	0.000	25.333	-0.104	778.663	288.396
11	4.000	0.000	21.333	-0.104	623.609	204.403
12	4.000	0.000	17.333	-0.104	489.363	133.148
13	4.000	0.000	13.333	-0.104	375.941	74.643
14	4.000	0.000	9.333	-0.104	283.385	28.945
15	4.000	0.000	5.333	-0.104	51.866	0.000

PRINTOUT OF NUMERICAL MODEL FOR THE FRAMEBENDER
(Straightening Tape)

FIG. II - 9

S...
0005015000
L3
TAPE 80501-500
REV NO 1
DATE 09/04/79
JOB
DB JOB ....
STOCK S-2079
L4
s
TAPE NO. 00-0501-500-01
BEAM ID 501 BUILT-UP ANGLE
BEAM LENGTH REQ. 61-08-00/16
PC. ID. STOCK S-2079
0 STABILIZERS REQ.
BEAM FLG. DOWN
USE S. CLAMP
s
S137,1061
R104
H0
M5
M0
M0
F5800
P4800
W52,0
X+6400Y-124
F4800
P4800
W283,29
X+11200Y-124
F4800
P4800
W376,75
X+16000Y-124
F4800
P4800
W489,133
X+20800Y-124
F4800
P4800
W624,204
X+25600Y-124
F4800
P4800
W779,288
X+30400Y-124
F4800
P4800
W955,385
X+35200Y-124
F4800
P4800

PRINTOUT OF PAPER TAPE CONTENTS FOR STRAIGHTENING

FIG. II - 10

SHIPDS-SHIPLO: A TWO-PHASE PROGRAMMING SYSTEM FOR THE DESIGN OF SURFACES IN SHIPBUILDING

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SHIPDS - SHIPLO

A TWO PHASE PROGRAMMING SYSTEM FOR SURFACE REPRESENTATION IN SHIPBUILDING AND ENGINEERING

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ABSTRACT

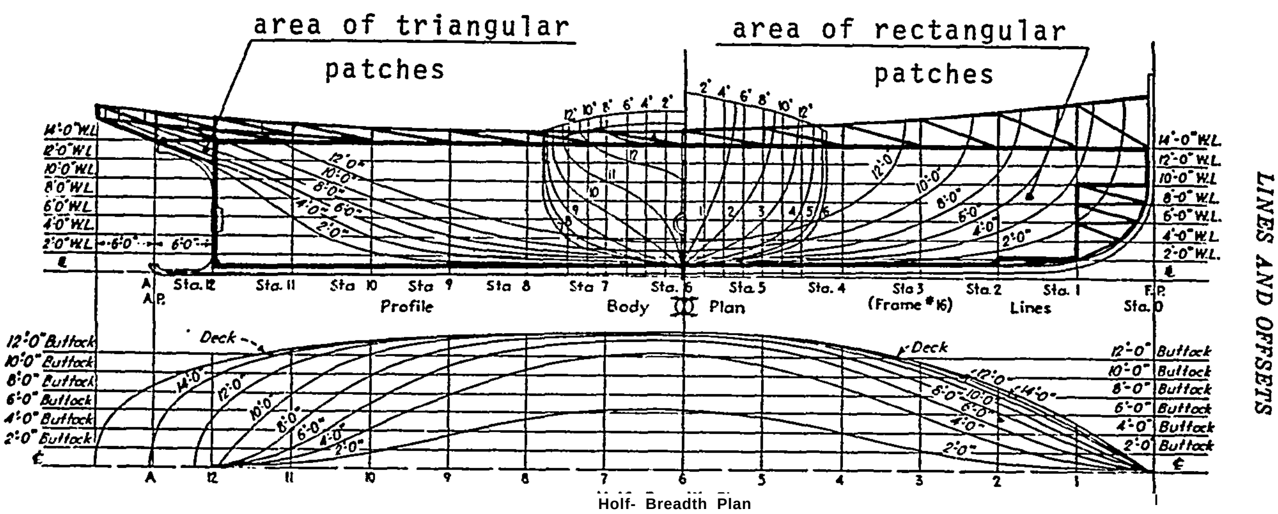
Several types of surface interpolation techniques exist which are defined over triangular or rectangular surface patches. They all have proven their usefulness in Computer Aided Design.
This paper describes a first approach to a programming system that combines triangular and rectangular interpolation methods and applies them to a typical design problem in shipbuilding, the representation of a ship hull.
The system is designed such that it requires only those data which are available from a common shiplines graph and produces the output in the most general form, i.e. as a set of points (X,Y,Z(X,Y)) for the single patches. This output will then be processed in a post-processor fashion by some particular graphical or production device.

INTRODUCTION

Computer Aided Geometric Design (CAGD) is a specialized field in Computer Aided Design (CAD) and focuses on the mathematical representation of arbitrily shaped univariate curves and bivariate surfaces. It provides several interpolation methods which already have been incorporated in the design process in many companies.

Interpolation over rectangular and triangular surface patches are two important schemes used for surface representation. They have been used mainly to provide the surface data of arbitrarily shaped objects for the purpose of stress analyses and aerodynamic computations. However, the two schemes have not been applied in conjunction with one another yet to solve design problems. Therefore optimal design features for general purpose applications have not been achieved yet, because previous design systems were strongly affected by the advantages and disadvantages of the single methods.

One of the objectives of the project to be described in this paper was to combine the advantages of these two methods and to eliminate or at least reduce the disadvantages to a minimum. Thus the efficiency of the rectangular interpolation schemes is exploited in parts of the surface (e.g. mid-section of a ships hull) where rectangular patches can be used without any problem. For the more complex shaped parts of the surface (e.g bow and stern of a ship) the more elaborate but therefore more adaptable triangular schemes are employed (see Fig. 1).



Harbor tug Hunlinglon, lines plan. Length, 100 ft., 0 in. over-all, JO3 ft. 0 in. B.P., beam, 20 ft., 0 in., depth, 14 ft., 6 in.

Fig. 1: Areas of rectangular and triangular interpolation on a ship hull surface

The programming system for the surface representation is not intended to be used for interactive ship hull design or fairing. It is meant for the more production oriented phase of the entire design process, at which stage a fairly accurate lines graph (e.g. ship lines graph) is expected to be available.

1. PROGRAM DESCRIPTION

1.1 Input Data for the Program SHIPDS

C^0 - and C^1-data which can be obtained from the ship lines graph are the only input to the programming system. These are the positional (Xi, Yi, Z(Xi,Yi)) and the slope (DZ(Xi,Yi)/DX, DZ(Xi,Yi)/DY) data at each of the vertices of the single patch i (see Fig. 2).

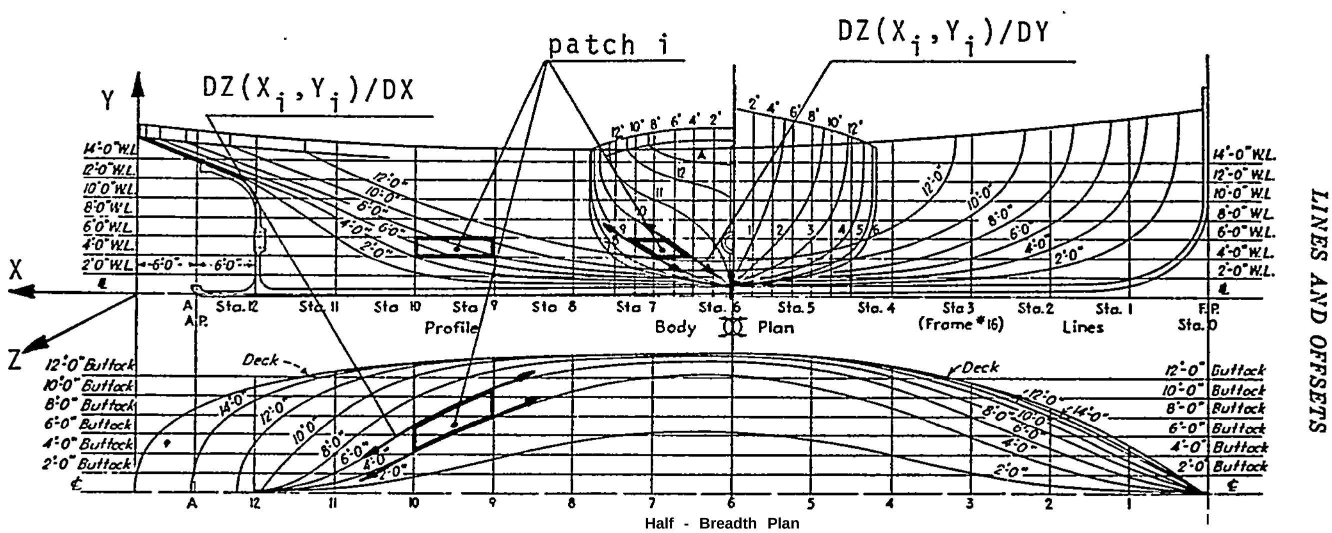
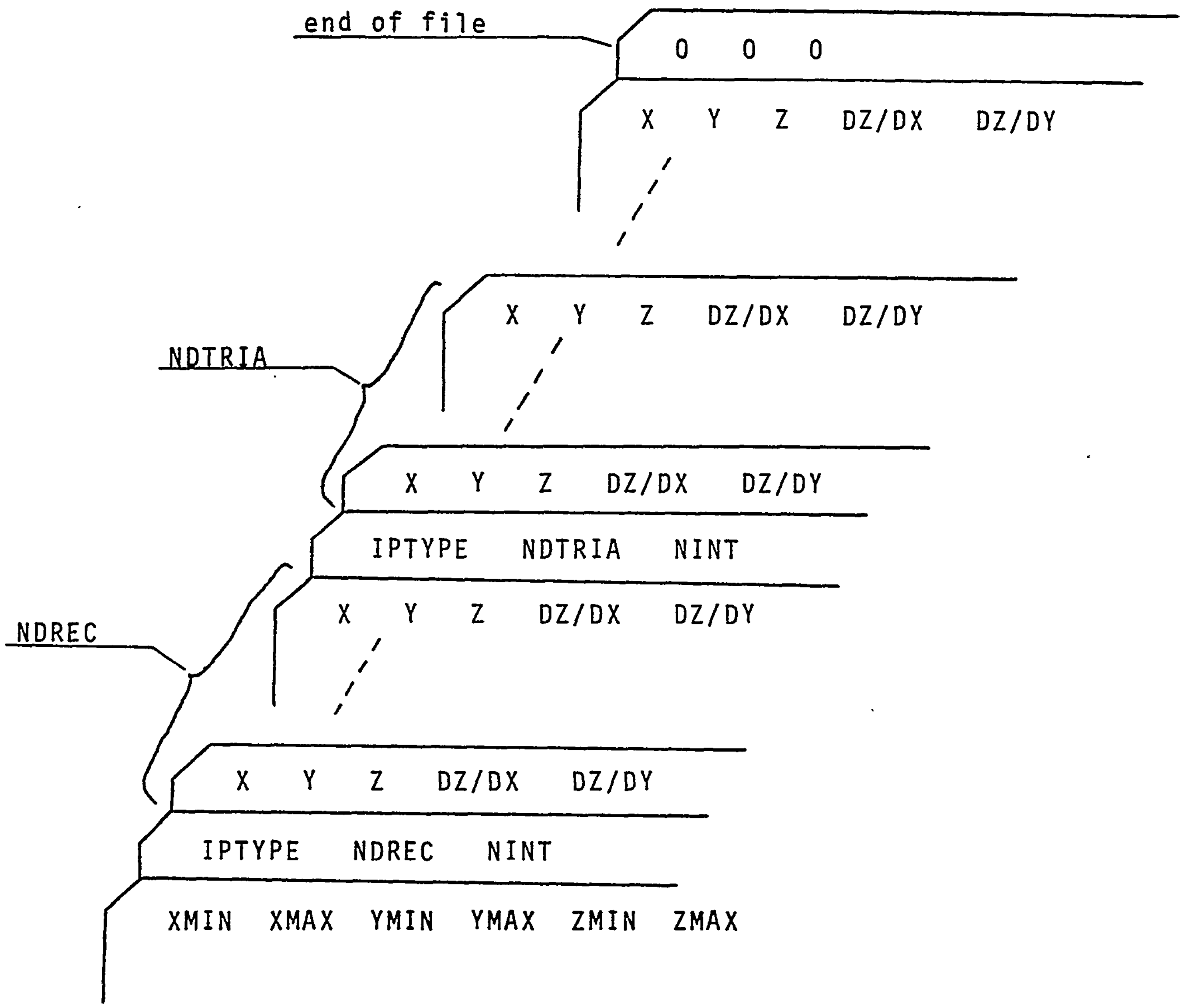


Fig. 2: C^0- and C^1 - data obtained from the ship lines graph

The patches can be defined easily on the grid that is used to draw the ship lines. But it does not need to be the same grid if bigger patches are sufficient for the required interpolation accuracy.

The principal input sequence in form of data cards is shown in Fig. 3. Fig. 4 illustrates this sequence in the form of records in a data file for the particular case of harbor tug Huntington /7/.



NDREC = number of rectangular patches in a set
NDTRIA = number of triangular patches in a set
IPTYPE = patch type, 3: triangular patch, 4: rectangular patch
NINT = number of intervals on the interpolated patch
X,Y,Z = position at each vertex of the patch
$\frac{DZ}{DX}$, $\frac{DZ}{DY}$ = gradient at each vertex of the patch
XMIN, YMIN, ZMIN = lower limits for the X, Y, Z data
XMAX, YMAX, ZMAX = upper limits for the X, Y, Z data

Fig. 3: Principle sequence of input data for the program SHIPDS

```
0.0    108.0   -54.0    54.0    54.0    54.0
4       36      5
  0.0   10.0    0.0     0.44    0.00  }
  8.0   10.0    3.5     0.44    0.34  }  1. rectangular patch
  0.0   12.0    0.0     0.53    0.00  }
  8.0   12.0    4.2     0.50    0.25  }
  0.0   12.0    0.0     0.53    0.00  }
  8.0   12.0    4.2     0.50    0.25  }  2. rectangular patch
  0.0   14.0    0.0     0.60    0.00  }
  8.0   14.0    4.8     0.53    0.15  }
  8.0    2.0    0.0     0.04    0.54
 16.0    2.0    0.8     0.09    1.09
  8.0    4.0    1.0     0.14    0.50
 16.0    4.0    3.0     0.28    1.00

   .
   .

3     10      5
  8.0   10.0    3.5     0.44    0.34  }
  0.73   8.0    0.0     0.28    0.15  }  1. triangular patch
  0.0   10.0    0.0     0.44    0.00  }
  8.0   10.0    3.5     0.44    0.34  }
  0.73   8.0    0.0     0.28    0.15  }  2. triangular patch
  8.0    8.0    2.8     0.39    0.38  }

   .
   .
   .

3     2      5
 96.0    12.0    5.0   -1.38    4.00
 97.8    14.0    8.6   -0.94    1.75
 96.0    14.0    9.5   -0.54    1.31
102.0    14.0    0.0   -4.50    9.42  }
 97.8    12.0    0.0   -3.00    6.28  }  last triangular patch
 97.8    14.0    8.6   -0.94    1.75  }
0     0      0
```

Fig. 4: Example of an input sequence illustrated on the harbor tug Huntington

There is no restriction imposed on the order of patch definition nor on the number of patches in a set. The variable NINT controls the grid size on which the interpolation values are computed or, in other words, controls the density of interpolation points on a surface patch. The values zero for the patch type IPTYPE, number of patches NPATCH and number of intervals on a patch NINT, signal the end of the input stream and terminate the execution of the program SHIPDS.

1.2 Output Data from the Program SHIPDS and Input Data for the Program SHIPLO

All patches are processed independently and sequentially as they are defined in the input stream (see Fig. 3 and Fig. 4). Therefore the sequence of output data from the program SHIPDS is of similar form. Each interpolated patch is described accordingly by a set of triples, the coordinates of the interpolated points X,Y,Z(X,Y). Fig. 5 illustrates the principal arrangement of the output data in form of data cards. Fig. 6, however, demonstrates this arrangement for the particular case of harbor tug Huntington in the form of records in the output file.
Here also the values zero for the patch type IPTYPE and the number of interpolated points on the patch NDRES indicate the end of the output file from the program SHIPDS.

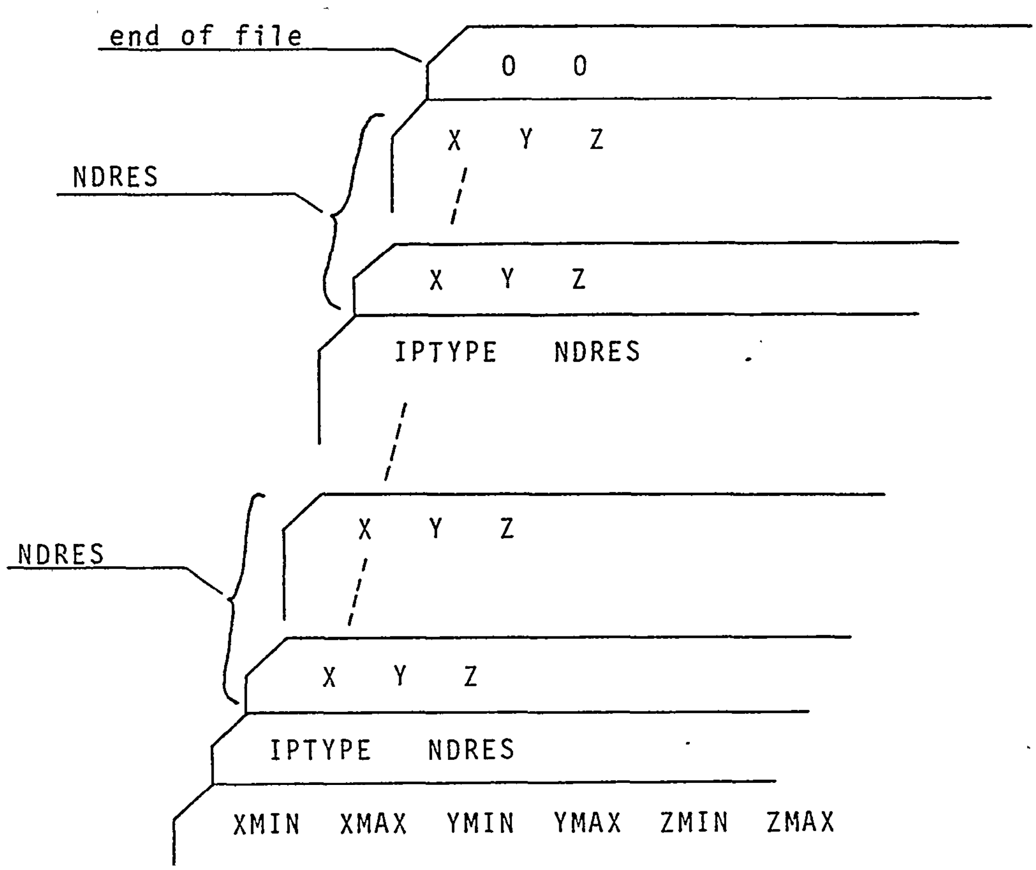
The output data from the program SHIPDS are also treated as input data to the program SHIPLO, which represents any kind of graphical or production device.

It should be mentioned that the interpolation points are computed on a grid of lines with constant values of the free variables. This property normally can be exploited by the interface program for the plotting device. In case of rectangular patches the grid of the interpolation points coincides with the X = const. and Y = const. lines (see Fig. 7). In the case of triangular patches, however, the points are computed on lines with constant barycentric coordinates. Those lines are parallel to the edges of a triangular patch (see Fig. 7).

1.3 Structure of the Programming System SHIPDS - SHIPLO

The system is called a "two phase" programming system, since it is separated into two distinct, and to some extent independent, parts.

SHIPDS represents the "first phase" of the system and performs the interpolation computations over the rectangular or triangular patches. The main objectives for the design of this part of the system were portability and flexibility. This could be accomplished by using standard FORTRAN IV as the most widely used programming



IPTYPE = patch type; 3:triangular patch; 4: rectangular patch

NDRES '= number of data for single patch

X,Y,Z = coordinates of the interpolated points on the patch

XMIN, YMIN, ZMIN = lower limits for the X,Y,Z data (from input-file)

XMAX, YMAX, ZMAX = upper limits for the X,Y,Z data

Fig. 5: Principle sequence of output data from the program SHIPDS and sequence of input data for the program SHIPLO

```
.000000E+00  108.000    -54.0000    54.0000    -54.0000    54.0000
    4     36
.000000E+00  10.0000      .000000E+00
.000000E+00  10.4000      .000000E+00
.000000E+00  10.8000      .000000E+00
.000000E+00  11.2000      .000000E+00
.000000E+00  11.6000      .000000E+00
.000000E+00  12.0000      .000000E+00
1.60000      10.0000      .701920
1.60000      10.4000      .732037
1.60000      10.8000      .763048
1.60000      11.2000      .794062
1.60000      11.6000      .823938
1.60000      12.0000      .851520
3.20000      10.0000      1.40096
.
.                                        first rectangular patch
.

4.80000      12.0000      2.55264
6.40000      10.0000      2.79808
6.40000      10.4000      2.91963
6.40000      10.8000      3.04862
6.40000      11.2000      3.17573
6.40000      11.6000      3.29159
6.40000      12.0000      3.38688
8.00000      10.0000      3.50000
8.00000      10.4000      3.64384
8.00000      10.8000      3.79632
8.00000      11.2000      3.94688
8.00000      11.6000      4.08496
8.00000      12.0000      4.20000

.
.
.

    3     21
97.8000      14.0000      8.60000
97.8000      13.6000      7.65952
97.8000      13.2000      6.27456
97.8000      12.8000      4.49984
97.8000      12.4000      2.39008
97.8000      12.0000      .000000E+00
98.6400      14.0000      7.80506
98.6400      13.6000      6.62360
98.6400      13.2000      5.01034
98.6400      12.8000      2.79933          last triangular patch
98.6400      12.4000     -.319996E-02
99.4800      14.0000      6.81869
99.4800      13.6000      5.19569
99.4800      13.2000      3.08825
99.4800      12.8000      .145519E-08
100.320      14.0000      5.36979
100.320      13.6000      3.13624
100.320      13.2000      .479994E-02
101.160      14.0000      3.18726
101.160      13.6000      .639985E-02
102.000      14.0000      .000000E+00
    0      0
```

Fig. 6: Example of an output sequence (harbor tug Huntington)

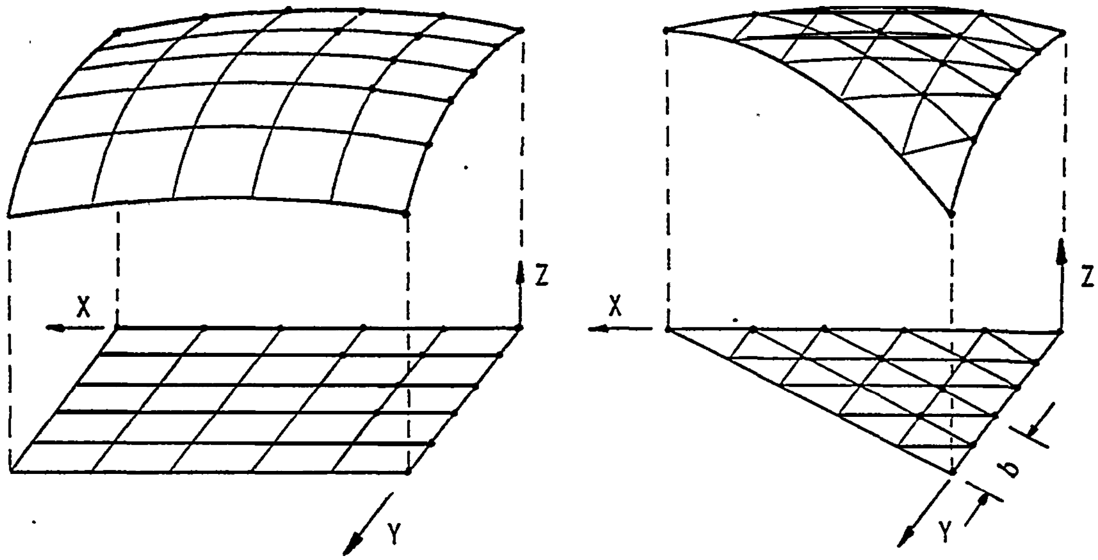


Fig. 7: Interpolation grid of a rectangular and triangular surface patch

language in engineering and by following strictly the rules of the standard.
Exploiting the FUNCTION- and SUBROUTINE-features the program SHIPDS could be designed in a very modular structure (see Fig. 8), such that the rectangular and triangular interrpolation schemes as a whole could be replaced by other techniques easily. This also permits the use of those interpolation programs in other than just the SHIPDS-environment.

The programs RPINT for rectangular patch and TPINT for triangular patch interpolation themselves are of very modular structure. Thus different techniques for interpolating the edge functions of a patch or approximating tangential and cross boundary derivatives along the edges could be substituted by better and/or more appropriate ones.

The freedom of choice for the different interpolation methods, however, is restricted by the type of data they need. Since most techniques do not require more than the C - and C - data as described in chapter 1.1 at the vertices of a patch and since those data all can be obtained from the ship lines graph (see Fig. 2), the system deliberately was confined exclusively to those data.

The output data from SHIPDS and also input data for SHIPLO had to be provided in a most general form, because the type of graphical or production device is not known in advance and will vary from application to application. The essential information each kind of graphical or production device will need is the coordinates of the interpolation points on a patch together with the number of points thereon and the code for the type of the patch (see Fig. 5 and Fig. 6).

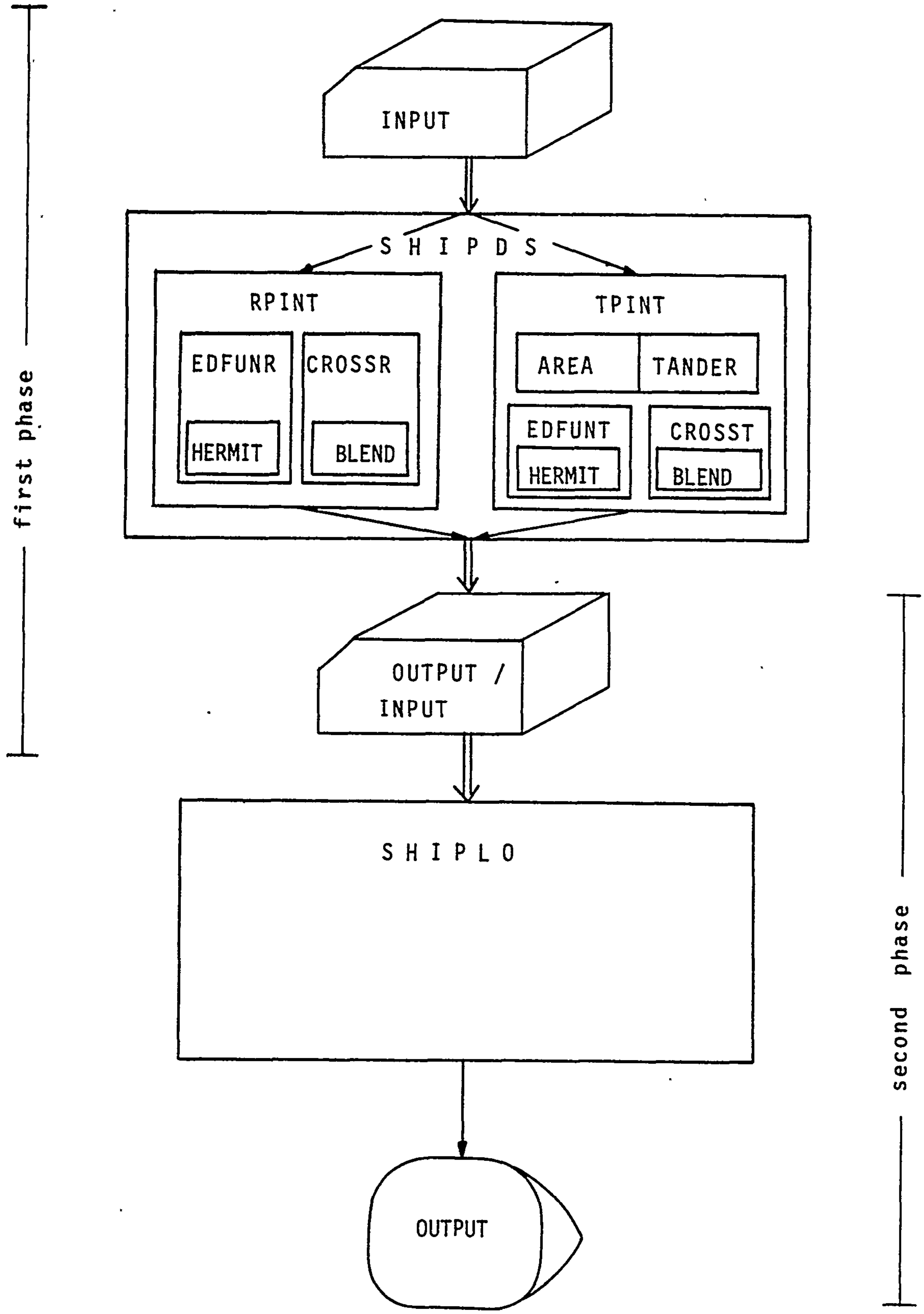


Fig. 8: Structure of the programming system SHIPDS - SHIPLO

The "second phase" of the programming system, represented by the program SHIPLO, is highly device dependent. It is an interface program that needs be modified or completely rewritten new application of the system. It, therefore, was written as a single program and very closely adjusted to the output device.

2. THEORY

2.1 Interpolation Schemes over Rectangular Patches

The parametric interpolation method over rectangles was introduced by S. A. Coons /1/. Therefore they are also called "Coons" patches.

This method uses the boolean sum $(P1 \oplus P2)F$ that interpolates to the values of the corners and edges of a rectangular patch. It is defined as follows:

$$(P1 \oplus P2)F = P1F + P2F - P1P2F \tag{1}$$

with the projectors

$$P1F = \begin{bmatrix} h0(u) & h1(u) & \overline{h0}(u) & \overline{h1}(u) \end{bmatrix} \begin{bmatrix} F(0,v) \\ F(1,v) \\ F10(0,v) \\ F10(1,v) \end{bmatrix} \tag{2}$$

$$P2F = \begin{bmatrix} F(u,0) & F(u,1) & F01(u,0) & F01(u,1) \end{bmatrix} \begin{bmatrix} h0(v) \\ h1(v) \\ \overline{h0}(v) \\ \overline{h1}(v) \end{bmatrix} \tag{3}$$

$$P1P2F = \begin{bmatrix} h0(u) & h1(u) & h0(u) & h1(u) \end{bmatrix} \begin{bmatrix} B \end{bmatrix} \begin{bmatrix} h0(v) \\ h1(v) \\ \overline{h0}(v) \\ \overline{h1}(v) \end{bmatrix} \tag{4}$$

and with

$$B = \begin{bmatrix} F(0,0) & F(0,1) & F01(0,0) & F01(0,1) \\ F(1,0) & F(1,1) & F01(1,0) & F01(1,1) \\ F10(0,0) & F10(0,1) & F11(0,0) & F11(0,1) \\ F10(1,0) & F10(1,1) & F11(1,0) & F11(1,1) \end{bmatrix} \tag{5}$$

and the cubic Hermite functions

$$\begin{aligned} h0(t) &= (1-t)^2 (2t+1) & \overline{h0}(t) &= (1-t)^2\, t \\ h1(t) &= t^2 (-2t+3) & \overline{h1}(t) &= t^2 (t-1), \quad t \in [0,1]. \end{aligned} \tag{6}$$

$$F(u,0),\; F(u,1),\; F(0,v),\; F(1,v) \qquad (7)$$

denote the edge functions of the patch (see Fig. 9) and

$$\left.\begin{matrix} F01(u,0) \\ F01(u,1) \end{matrix}\right\} = \left\{\begin{matrix} DF(u,0)/Du \\ DF(u,1)/Dv \end{matrix}\right\} \text{and} \left\{\begin{matrix} F10(0,v) \\ F10(1,v) \end{matrix}\right\} = \left\{\begin{matrix} DF(0,v)/Du \\ DF(1,v)/Dv \end{matrix}\right. \qquad (8)$$

denote the cross boundary derivatives along the edges.

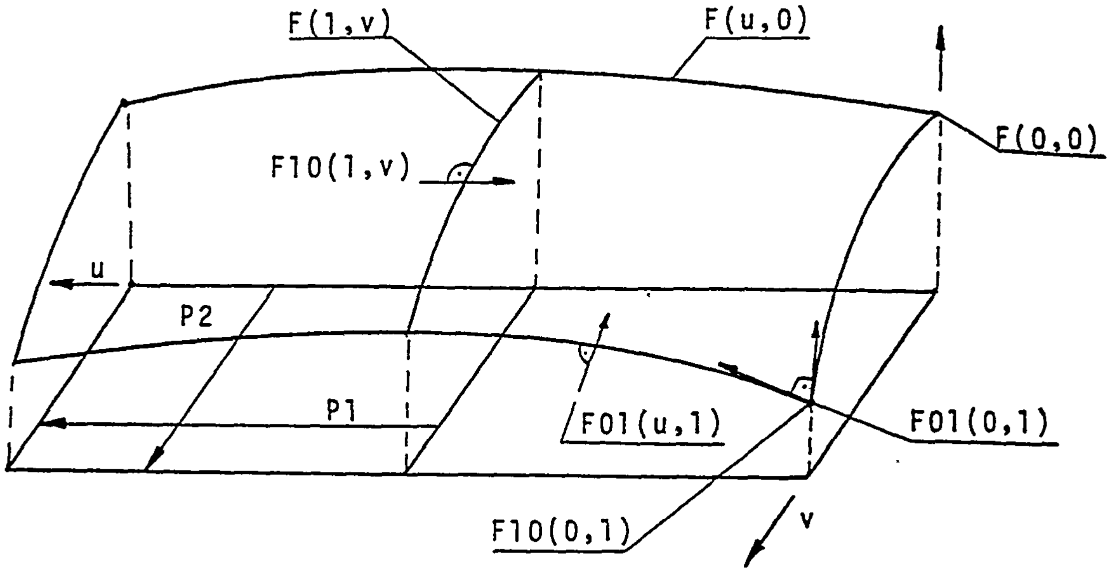


Fig 9: Bicubically blended Coons patch

The edge functions are also interpolated by cubic Hermite functions (see (6)) using the C - and C -data provided as input for each patch (see chap. 1.1):

$$F(u,1) = \begin{bmatrix} h0(u) & h1(u) & h0(u) & h1(u) \end{bmatrix} \begin{bmatrix} F\ (0,1) \\ F\ (1,1) \\ F10(0,1) \\ F10(1,1) \end{bmatrix} \qquad (9)$$

$$F(1,v) = \begin{bmatrix} h0(v) & h1(v) & h0(v) & h1(v) \end{bmatrix} \begin{bmatrix} F\ (1,0) \\ F\ (1,1) \\ F01(1,0) \\ F01(1,1) \end{bmatrix} \qquad (10)$$

The cross boundary derivatives are linearly blended together:

$$F01(u,1) = (1-u)\ F01(0,1) + u\ F01(1,1) \qquad (11)$$

$$F10(1,v) = (1-v)\ F10(1,0) + v\ F10(1,1) \qquad (12)$$

The use of the cubically blended Coons patch generally suffers from the approximation of the twist partition in the matrix B:

$$T = \begin{bmatrix} F11(0,0) & F11(0,1) \\ F11(1,0) & F11(1,1) \end{bmatrix}. \tag{13}$$

In order to keep the problem simple, the twist partition T is approximated by zero. But it normally does not result in a sufficient surface interpolation. One of several different techniques for approximating the twist terms is the so called "Gregory's Square" which is a 12-Parameter scheme (see /2/ for more details).

Since adjacent patches have the same positions and gradients at the patch vertices as obtained from the ship lines graph and since their common edge functions are interpolated by the same cubic Hermite functions and the cross boundary derivatives by the same linear blends, the surface represented by rectangular patches must be a C^1-surface.

2.2 Interpolation Schemes over Triangular Patches

Barnhill, Birkhoff and Gordon (BBG) initiated in 1973 /9/ the "triangular" Coons patch by applying the boolean sum to the three projectors of the standard triangle (see Fig. 10):

$$(Pi \oplus Pj)F = PiF + PjF - PiPjF \qquad i,j=1,2,3 \quad i\#j \tag{14}$$

with

$$P1F = \begin{vmatrix} h0(r) & h1(r) & h0(r) & h1(r) \end{vmatrix} \begin{bmatrix} F & (0 & ,q) \\ F & (1-q & ,q) \\ F10 & (0 & ,q) \\ F10 & (1-q & ,q) \end{bmatrix} \tag{15}$$

and

$$r = P/(1-P) \; . \tag{15}$$

P2F and P3F are defined analogously. This interpolant interpolates to the values at the corners and edges of the standard triangle.

In order to apply the BBG-interpolant to an arbitrary triangle affine transformations on the standard triangle need to be performed. Positions and directions of the tangential derivatives are preserved under affine transformation but not the directions of the cross boundary derivatives. Therefore they need special treatment as described in more details in /2/ and /4/.

The "Brown - Little" triangle, however, is a C^1-interpolation scheme for arbitrary triangles that interpolates to the values at the corners and edges of the triangular patch:

$$(BL)F = A*P1 + B*P2 + C*P3 \tag{17}$$

with the weight functions

$A = b2^2*b3^2/D \qquad B = b1*b3^2/D \qquad C = b1^2*b2^2/D$ and

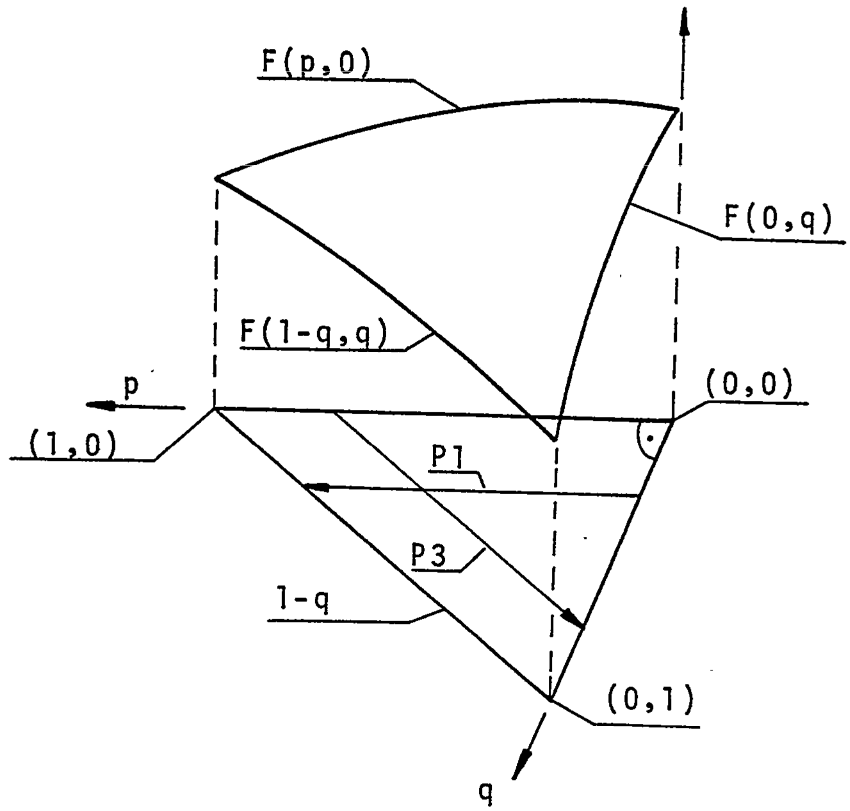


Fig. 10: BBG - interpolant on standard triangle

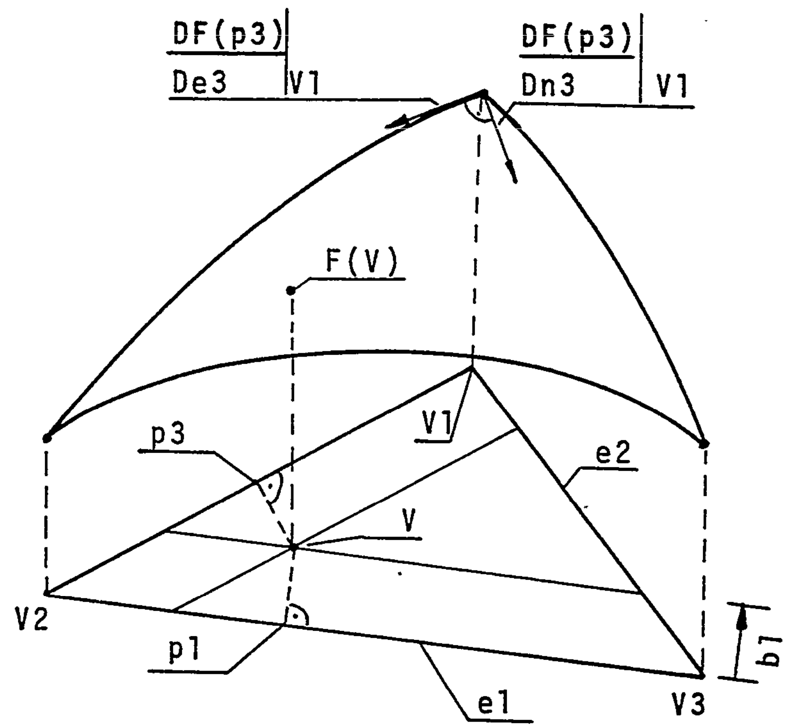


Fig. 11: Brown - Little triangle

$$D = b1^2 * b2^2 + b1^2 * b3^2 + b2^2 * b3^2 \qquad (18)$$

The bi, i=1,2,3 are the barycentric coordinates at the point V with the property:

$$b1 + b2 + b3 = 1 \qquad (19)$$

The physical coordinates X, Y can be computed by:

$$X = \sum bi*Xi, \qquad Y = \sum_{i=1}^{3} bi*Yi \; . \qquad (20)$$

The projectors PiF are defined as follows:

$$PiF(X,Y) = [(F(pi) + bi*2AR)/[Vi+1 - Vi+2]] * DF(pi)/Dni \qquad (21)$$

where AR denotes the area of the projection of the triangular patch onto the XY-plane and DF(pi)/Dni the cross boundary derivative along edge i. The Vi's are the patch vertices and the pi's are the parameters which vary between the values of the vertex coordinates, which enclose the same edge. They are the projections of an arbitrary chosen interpolation point V within the patch onto the single edges (see Fig. 11).

In the case of the triangular patches the edge functions are also interpolated by cubic Hermite functions using the C^0 and C^1-data from the graph. Since adjacent patches need to have at least one edge in common, the two corresponding vertices need to have the same positional and slope data at those points, which are computed from the gradients. Therefore the edge functions of adjacent triangular but also adjacent triangular and rectangular patches will be identical and the surface constructed from the triangular patches will be C^1.

3. RESULTS

3.1 Computational Problems

In the first stage of designing the programming system SHIPDS-SHIPLO, most of the concern was dedicated to the program organisation (see chap. 1.3) rather than to the perfection of the interpolation programs. Therefore those.interpolation programs, which were already available, have been adopted accordingly to the requirements of the program organisation. Thus the bicubically blended Coons patch with the zero twist partition (see (1) and (5)) for the rectangular patches and the Brown-Little triangle (see (16)) for triangular patches have been implemented.
The results are shown in Fig. 12. They are surely not satifactory yet for most "real world" applications. The poor quality of the interpolation is partly caused by the inaccuracy of the input data, which have been manually read off the graph shown in Fig. 1 and

Fig. 2.

The cubic Hermite functions for interpolating the edge curves of the surface patches have been used in nonparametric form so far. This also creates problems, since their interpolation accuracy decreases very fast with the increase of the slopes of the tangents at the patch corners.

* The tangential and cross boundary derivatives needed for both the triangular and rectangular patches are computed from the gradients at the vertices. In case of the rectangular patches, in fact, they are identical with the gradient components and this part of the ships hull surface indeed is a C^1- surface and interpolates correctly over its entire region.

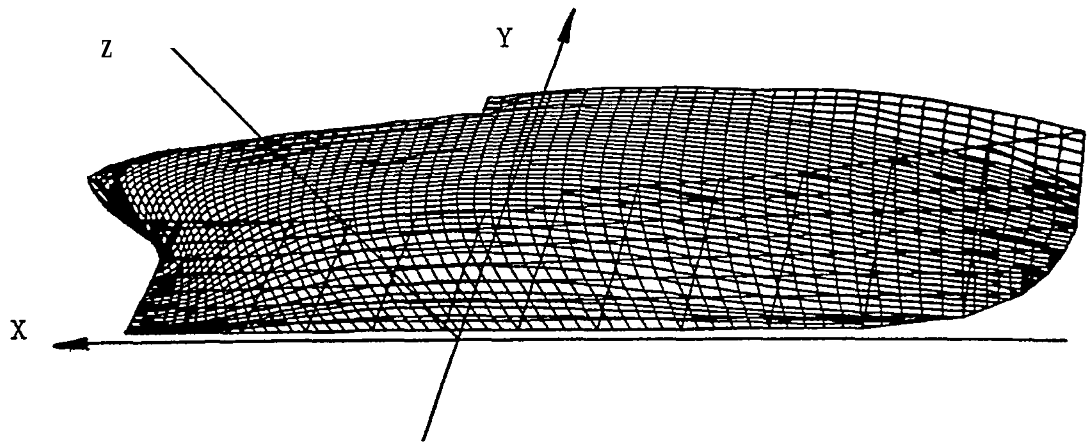
The triangular interpolation scheme also interpolates a C* surface as expected. But the local, (i.e. in the interior of the patch) interpolation accuracy, especiallv in parts of the surface of high curvature as the stern of the ship, is very low. Noncollinear edges of triangular patches along the surface boundaries, on the other hand, create an inconsistency for the local interpolation along the boundaries. This problem has not yet been solved theoratically and results in inaccurate interpolation along the surface boundaries. It will depend on the type of the surface as well as on the- particular application wether the final interpolation will be sufficient or if other correction steps have to be taken (see Fig. 12 and Fig.13).

Discontinuities in a smooth surface as they might be intended and occur in the case of the harbor tug Huntington (see Fig. 1 and Fig. 2), can successfully be treated. But they have to be restricted to follow exactly the edges of just the rectangular patches.

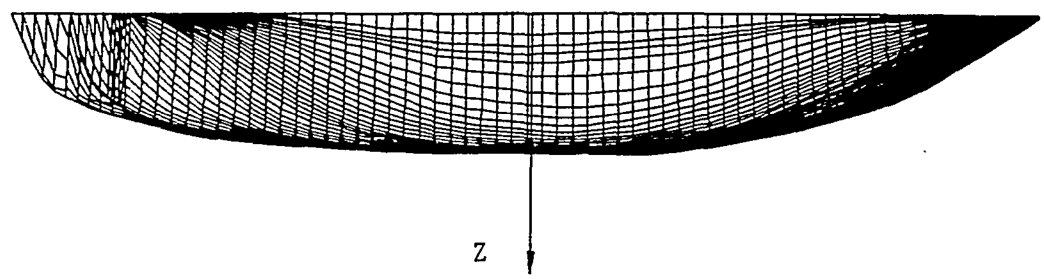
3.2 Graphical Problems

As example for the output device for the “second phase” of the system a TEKTRONIX - storage tube has been chosen, that was equipped with a transformation package to create 3-D images.

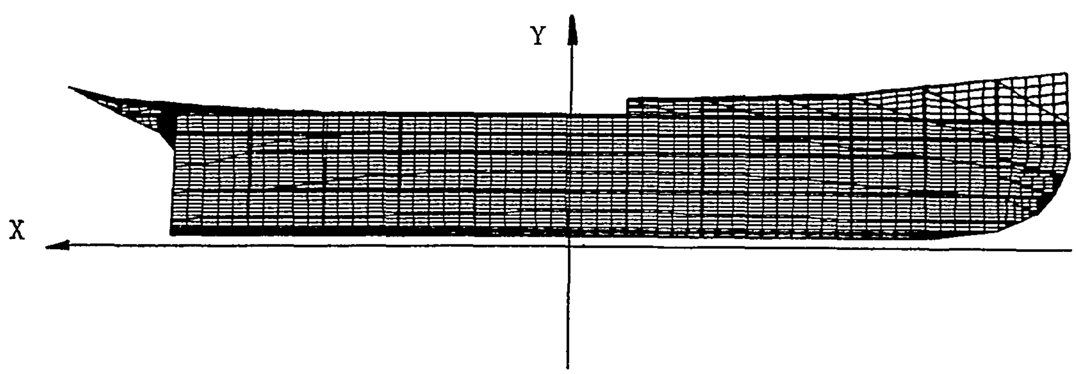
In order to obtain a reasonable impression of a 3-D image on a 2-D TEKTRONIX - screen a regular texture on the surface patches is needed. This can be accomplished easily for rectangular and triangular patches separately. But since the interpolation points of the triangular and rectangular patches are computed on different grids (see chap. 1.2 and Fig. 7) it is not easy to achieve a completely homogeneous texture on this kind of graphical device and thus avoid the considerable distortion of the principally correct results.



Harbor tug Huntington (3-D front view)



Harbor tug Huntington (top view)



Harbor tug Huntington (side view)

Fig. 12: First results from the programming system SHIPDS - SHIPLO

4. NECESSARY AND POSSIBLE IMPROVEMENTS

In order to obtain results that are acceptable for 'real world" applications of the system some improvements have to be achieved. Thus the rectangular interpolation scheme with the 'twist approximation equal to zero has to be replaced by a better method.
The triangular interpolant, the Brown-Little triangle, is known for its poor approximation of the interior of the patch. It also will be substituted by an acknowledged better method; Because of the modular structure of the program SHIPDS those changes can be performed easily.

The nonparametric interpolation used for the edges of the triangular and rectangular patches will be sufficient for many problems. It is desirable, however, to implement a parametric version in order to be more general and to avoid problems with extrem slope values as they occur at the bottom and the stern of a ships hull.

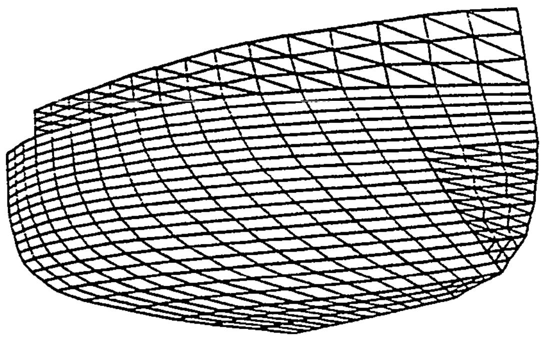
As Fig. 13 can prove those "better" interpolation schemes are avilable as part of the surface editor SURFED /8/ of the CAGD group at the University of Utah. The triangular and rectangular methods can be combined in order to represent a complex surface efficiently like the one of a ships hull,
For the particular instance of the harbor tug Huntington (see Fig. 13) the more advanced methods, which have been applied, are a modified version of the "Gregory's Square" - method that can even interpolate quadrilateral patches as a superset of rectangular patches and the BBG - method for arbitrary triangles.

CONCLUSION

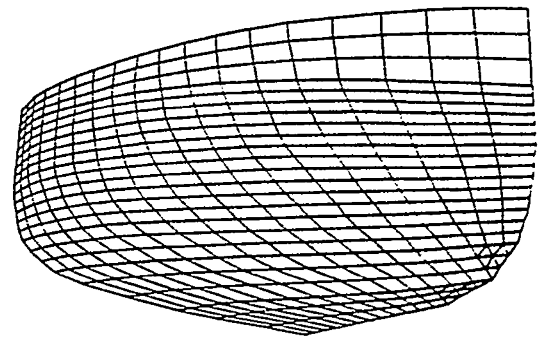
The current version of the two phase programming system has proven that the program organisation can meet the expectations for a production oriented application. The objectives of portability, generality, flexibility and efficiency can be achieved.

The quality of the interpolation or, better, of the representation of a complex shaped surface depends very much on the methods chosen. There are several methods available that can be incorporated into the system and that allow to combine triangular and rectangular patches and thus exploit the efficiency of the rectangular interpolation schemes with the accuracy of global shape approximation of the triangular patches.

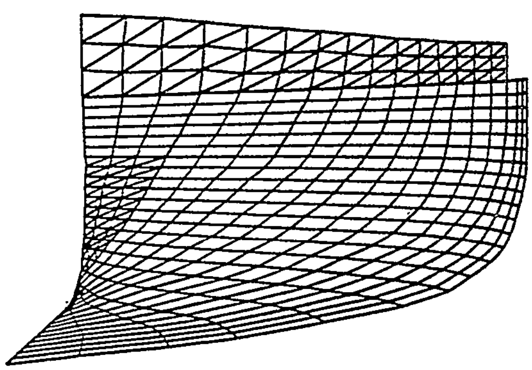
The second phase of the current version of the programming system was designed and performed for the purpose of illustration rather than for final application. It will have to he changed for a particular application of graphical or production device.



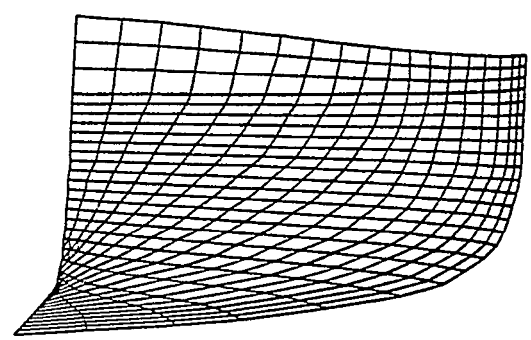
triangular and rectangular patches (front view)



triangular and quadrilateral patches (front view)



triangular and rectangular patches
(front view from the inside)



triangular and quadrilateral patches
(front view from the inside)

Fig. 13: Results from improved interpolation methods illustrated on harbor tug Huntington

Since the output data of the first phase are provided in the most general form and since the interpolation points are computed on a regular grid, the second phase of the programming system is not limited only to the pure interfacing task. It also could include simple numerical integration methods in order to provide additional features, such as the computation of volumes, centers of gravity etc. of various parts of the ship.

The system needs only very little core size (10K words), so that it can be installed even on smaller computers and thus offer its benefits also to the small shipbuilding and engineering companies.

AKNOWLEDGEMENTS

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AUTOKON'S NEW STRUCTURAL DESIGN CAPABILITIES MOVING IN TO THE DRAWING OFFICE

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The AUTHOR is indebted to collegues in SRS as well as to Mr. di Luca and his collogues at Italcantieri for contributions to the preparation of this paper.

SYNOPSIS

This paper describes new modules added to the batch AUTOKON, which have made AUTOKON very attractive for use in the drawing offices. By means of powerful and easy to use features, a computer based structural "model" of surfaces, stiffeners, etc. may be established at an early stage. This model may be interrogated to produce a variety of drawings for design and production purposes.

Benefits: Consistent and accurate drawings, reduction of routine drafting work, rapid transistion of design modifications into updated drawings, improved design coordination, fewer errors down stream. The "model" is available for lofting, will reduce loft hours and smoothen the peak load to generate N/C cutting information.

INTRODUCTION

The title of this paper seems to indicate that use of AUTOKON for drawing office purposes is an entirely new idea, which is not exactly true. Already in 1974/75 a library of ALKON design and production norms were applied in the Aker Group to build up a description of, the steel structure in the database at an early stage, generate drawings and utilize the database information for down stream processing in lofting. A simplified diagram of this procedure is shown in Exhibit 1.

The procedures really never got a break through in the drawing office. The reasons were many; collapse of the shipbuilding market, insufficient flexibility to handle different types of ships, high consumption of computer time, not easy enough to use and finally - the turn around of jobs in the batch enviroment did not lend itself to the effectiveness required.

However, another Aker Group development of an ALKON design and production norms library for jackets (tubular steel structures) turned out to be very successful and is in frequent use. Exhibit 2 is simplified diagram of the procedure.

The norms were defined in ALKON languge and to guide the reader he is referred to Exhibit 3 which shows the lay-out of the system on the AUTOKON-76 level.

Since the early 1970-ies, Italcantieri in Italy, an AUTOKON user since 1968, had been developing a stand alone system called SCAFO-DSI containing parallelsto the AUTOKON functions. By investigation we found that some SCAFO programs called TRALOS,TRADET AND DRAW, could replace the functions we tried to cover by the ALKON ship design norms library: to load internal surfaces with associated stiffening in a computer based structural model from which a variety of drawings could be generated.

We found the solution elegant, powerfull and easy to use. Italcantieri had been very faithfull to AUTOKON when intergrating the 3 programs, hence we found it would be easy to incorporate them in the AUTOKON package we offered. In 1978 SRS made an agreement with Italcantieri giving SRS exclusive world wide marketing rights to distribute these modules under the AUTOKON trade mark. Futher, we acquired 10 new ALKON statements, which replace a number of system norms (cutouts, contour generation, etc) which a substantial reduction in computer time consumption as result.

Together with a new lines fairing system BOF and the interactive nesting system AUTONEST, the enhanced system is labelled AUTOKON-79. For the US-user the differences between -71 and -76 are minor compared to the enhancements form -76 to-79.

In AUTOKON-79, we think we really have a system that should attract the drawing office.

This paper will mainly deal with the new software handling internal structures, since it means a boost to the use of AUTOKON at an early stage, However, the early availability of a numerical description of the hull form is a prerequisite to exploite TRALOS, TRADET and DRAW. Therefore some time is devoted to describe how BOF can cope with this demand.

BOF - THE AUTOKON -79 HULL DEFINITION SYSTEM

The use of AUTOKON -79 in design requires loading of a hull definition. There are basically 2 means to get it. Either a preliminary definition from PRELIKON transferred to the AUTOKON data base by the module FILIP/TRABO. Which means that all drawings from DRAW will be preliminary with regard to shell contours. This may be acceptable as a departure point, since the main objective is to get drawings. The other alternative is BOF.

Traditionally, computer fairing has been postponed until model testing wase finished, which is normally late in the design stage. The main reason has been the time and cost of doing lines fairing, even by computer. partly inability to handle local modifications in a reasonable way. Therefore better wait until everything was settled to avoid doing it all over again. For this reason hull fairing has always been a bottleneck leading to delays and peak load in lofting.

BOF makes it feasible to overcome this attitude and look on hull definition as a process that may be allowed to go through several iterations in time. Because it is easy to use, gives the user full control, allows local modifications without unexpected side effects, saves whatever information was acceptable in the previous stage, at less efforts and time. There is no longer a good reason to postpone fairing as before.

Besides that BOF can handle any hull form for surface and submarine vessels. Originally developed for the automotive and aircraft industries, BOF has been adopted to shipbuilding. The system has shown its versatility both in new construction, conversion and repairs.

BOF is a modular, command - oriented system operated in batch mode, with very powerful1 interrogation and verification facilities, BOF allows a complete description of the hull form and makes available much more information for down stream processing than the old FAIR module.

Exhibit 5 shows a layout of BOF functions, and its versatility in use appears from Exhibits 6, 7, 8, 9 and 10 which shows results.

BRIEF DESCRIPTION OF TRALOS, TRADET, DRAW

The main objective of this paper is to describe the "mechanics" of AUTOKON-79, the impacts on the shipbuilding process and organization and the advantages and benefits. Nevertheless, a brief description of TRALOS, TRADET and DRAW is considered necessary.

TRALOS

This module can cope with any type of longitudinal surface:

flat, curved, twisted or a combination of 3 geometrical conditions. The description of the surface is dependent on

its geometry, determined transversally and longitudinally by its geometric line configuration

its topology, determined transversally and longitunally by the adjacent surface delimiting its extension in space.

Surfaces are reduced into 2 types: Xsee Exhibit 11)

HSUR - mainly horizontally arranged
USUR - mainly vertically arranged

The module is also provided to handle non-symmetric extension even in presence of a non-symmetric body plan.

The module supplies the intersection points between the longitudinal surface boundaries and transversal plane in correspondence of transverse frame. Furthermore and for each transverse frame, ending points of every penetrating surface are printed.

TRADET

This module stores profiles, seams, minor structures and connections concerning inner structure. All profiles and seams have been reduced into a few family types upon their prevalent arrangement. They are further simplified by the conventional way they are usually represented.

In general, a detail belongs to a structural surface where it is mounted (profiles) or it devides the panel (seam). Thus it follows the way of surface representation which is usually done over three conventional views:

transversial view from aft to fore (web frames, transversal bulkheads, floors etc.);

longitudinal view from starboardside (longitudinal bulkheads, girders etc.);

longitudinal view from top (decks, tanktops, forecastle, etc).

Keeping in mind this way of representation, a detail like a profile could have only two different arrangements upon the face plate or flage orientation its scantling is referred to Exhibit 12
Each execution of a group of profiles the program prints production information as: profile code, scantling, pieces, type of endings, length.

DRAW

The whole internal structure is grapically represented by means of this module which is capable of generating drawings over the various extensions and conventional views of the hull. In short it is capable to furnish following:

scantling drawings of transverse sections;

scantling drawings of horizontal sections;

scantling drawings of vertical sections;

structural drawings of a transverse frame;

structural drawings of longitudinal surfaces.

By scantling drawings are meant the section of the actual penetrating structure as if it were "cut" by a plane. Typical example, see Exhibit 13 .
By structural drawings we mean the actual structure which, in addition of the mentioned scantling, includes also stiffeners, seams, holes, inner contours and standard symboles of various details. See example, Exhibit and 14 .

"Windowing" features make it possible to extract partial views of the structure. Therefore, from the same basic, input we may have both lay-out drawings, classification drawings or blockdrawings according to need.

AUTOKON-79 IN STRUCTURAL DETAILING

To have some reference to something established and well known, let us use computer lofting as base for comparison.

Basically and isolated, computer lofting implies

mechanization of highly repetitive tasks such as lines fairing and development of shell plates

converting part by part from drawing data into N/C cutting tapes with a minimum of input code, in fact a process which merely copies information from grapical into numerical form.

Computer lofting means a concentration of software usage in the end of the total preparation phase, as indicated by curve A) in Exhibit 16 . From an organizational point of view, the loft department is the responsible user. In most yards the drawing office has been only occasionally involved, if at all. However, the last 10 years of experience shows that the yards who have benefited most from N/C are those having a close cooperation between design and loft. The loft is merely copying a tremendous amount of detailed design decisions into numerical form. Hence, the drawing office has been able to greatly influence the efficiency of computer lofting by introducing design standards and preparing drawings in a way that utilize all the worksaving features of the software.

The new modules of AUTOKON-79 changed the described pattern and moves the center of gravity closer to the design stage. AUTOKON-79 makes the design office a prime user itself, not only a good collaborator as mentioned above.

THE APPROACH AND "MECHANICS" OF AUTOKON-79

The basic difference in the AUTOKON-79 approach compared to an isolated AUTOKON lofting is to establish a computer based "model" of the entire steel structure at an early stage. This "model" can be interrogated for generation of structural drawings and "harvested" down stream, f.inst. for lofting. The following features should be noted:

0 The structural model comprises shell and interal structures with surfaces, openings in surfaces, major and local stiffening as well as seams and butts.

- The internal structure is described in a straight forward way, easy to learn, and stored as a relational (topological) model in the data base. Which implies that the description is independent of the actual geometry and valid as long as the topological relations are the same.

- The model is built up step by step, starting with the global information and gradually increasing the detailing. By doing this in a way that reflects the hierarchy of the steel structure, a fairly high degree of automatic updating of drawings will be made when design modifications are introduced.

  Ex. 1

  A vertical bulkhead with stiffeners described as being delimited by deck A and B will be automatically updated if the distance between the decks is changed.

  Ex. 2

  That will also be the case with a number of local stiffeners described as delimited by two major stiffeners if the latter is subjected to a certain relocation.

- The model itself and consequently the drawings generated from it at any point of time, will be preliminary or final and more or less detailed depending on the extent of basic data' loaded into the computer.

  From a relatively simple model a variety of drawings may be generated quickly at an early stage. For example transverse section on every construction frame, plans and elevations at arbitrary locations, etc.

- The model is updated periodically to reflect all design alternations until it is final. Apart from having been an important tool for the drawing office to speed up generation of drawings, the model itself is available for later computer lofting. A very great deal of the information that the loft would otherwise have to lift from drawings and generate themselves, are now available as reference data.

  The described approach is symbolized by curve B) in Exhibit 16

Since AUTOKON-79 is a common tool for drawing office and loft, it is fully possible to restrict the application to lofting. Instead of the iterative approach the system then will be used as an advanced "copying device" just as was the case with previous versions in the past. This approach may be symbolized by curve C) in Exhibit 16.

AUTOKON-79 allows a number of tasks to be worked on in parallel1 as indicated in Exhibit 17 , which shows the work load versus time corresponding to curve B), in Exhibit 16. In Exhibit 18 the work load curves A), B) and C) correspond with the curved A), B) and C) in Exhibit 16. The curves clearly show the shift of work load and smoothing of the peak. Further they indicate the savings in manhours and lead time by using AUTOKON-79 in an integrated way from an early stage.

ADVANTAGES AND SAVINGS

After having elaborated the "mechanics" of AUTOKON-79, the advantages and savings of using the system in design may be summarized as follows:

Consistency and accuracy of data and drawings

Every design manager knows that drawings are not exactly to scale, and more than often a drawing shows inconsistency between different views.

No so with AUTOKON-79. No matter whether input data is correct, wrong, final or preliminary, the results will be consistently correct, wrong; final or preliminary for any section, elevation or plan affected by that particular input data. And the result of a design error will be just as numerically and graphically "accurate" as the result of its modification.-

The combination of data consistency and accuracy of results is the very foundation for the quality of information. Any time the model is referenced, a piece of information is always the same. On stable drawing paper, the drawings are "true" to an extent non-existent in a conventional office. This quality is of great importance for all parties using the structural drawings, directly or indirectly. The quality is also increased by the fact that certain data can be retrieved directly from the model in tabular from rather than taking measurements on the resulting drawing.

The model is a single and common source of information available to all draftsmen. It represents the "truth".

Rapid detailing and generation of drawings

Starting from a rather sketchy arrangement and a preliminary hull form, AUTOKON-79 can generate a variety of 'skeleton" drawings in desired scales. These drawings will serve as work documents for further design discussions. When additional details are decided, the input reflecting these decisions is loaded into the system, the model is updated and new drawings are generated.

The main advantage lies in the ease of interrogation of the model to obtain numberous sections, elevations, plans and views,which would otherwise have to be made by hand. Apart from saving drafting hours, the more elaborate drawings mean a considerably improved basis for checking against design flaws.

Rapid updating of drawings

Even a single update, such as location of a girder may affect a great number of structural drawings. The traditional way to save time for updating of drawings is to change dimensions only and leave the contours as they are. After a number of these "updates' the discrepancy between numerical and graphical information and result in design flaws.

AUTOKON-79 makes it possible to overcome these problems and have drawings to be "true".

More flexible drawing procedures

It has already been mentioned that the model can be interrogated to get a variety of drawings: sections, elevations, plans etc. A transverse bulkhead may be seen from aft or forward. Simple instructions may display the same information by different scales for different purposes. By special "window" instructions a deck or other structure may he split in parts and displayed on separate drawings in a different scale than the structural plan, such as when making block drawings. By thinking on the model in terms of "geometry" rather than steel structure alone, and by combining scaling and windowing the model can provide drawings as work documents for special purposes. Just imagine how many times the same contours are drawn over and over again in the various design departments.

The model ensures that this variety of drawing documents contains consistent information.

The above mentioned advantages are basically -concerned with the steel drawing office itself. There are, however, certain spin off effects that should not be overlooked.

Improved coordination of design functions

The hull form and steel structure establish the constraints for almost all outfitting design work. It is common practice that the outfitting design departments either take measurements from the steel drawings or simply place them under a transparency and start working form there. The more comprehensive the outfitting and the less space there is available, the more important is the quality of structural documentation.

AUTOKON-79 provides steel drawings or skeleton drawings that are more elaborate, flexible, consistent and accurate with less efforts. Higher quality means greatly reduced chances for design flaws, which can either be totally avoided or at least discovered at an early stage.

Improved material take-off.

Steel drawings are the basis for material take off and making the bill of material for steel. More often than not steel drawings are inconsistent, inaccurate, in a small scale and inadequate in the sense that they do not give sufficient information to the materials man. He has to do a lot of guessing and tends to add on plenty of green material to make the bill of materials safe againt shortage. The result is unnecessary increase in material costs. For small vessels using standard stock plate sizes this aspect means less than for tailormade orders for very large ships, where each 1% additional allowance may mean US $30-70.000 in purchase costs.

AUTOKON-79 does not only provide high quality drawings for this purpose. The system prints tables with length of frames and stiffeners. For shell plates the bill of material is generated automatically except for certain limitations in the extreme bow and stern.

Reduced lofting work.

The detailed computer model is available as reference for the loft. The drawing office has generated "N/C information" that was the job of the loft. This should not be regarded as a transfer of work load from loft to design. The drawing office will use AUTOKON-79 because it is advantageous in their own work. As spin off the loft will benefit by saving some of their work. Why should the same information have to be defined and loaded twice into the computer? And - what is the difference between a "design contour" and a "lofting contour"? By tradition the first is inaccurate and the latter accurate. In terms of AUTOKON-79 it is the same thing.

THE AUTOKON-79 ENVIRONMENT

The tangible and intangible savings and benefits from AUTOKON-79 are dependent on a number of human and physical conditions outside of the system itself; skill and attitude of the staff and access to hardware.

The operational environment may have a dramatic impact on the lead time of jobs. Good turn around - i.e. the elapsed time from the user delivers his input data to the system until he has all the requested results in hand - tends to reduce working hours as well. Because it allows him to finish his job when he is mentally engaged in it, rather than resume it the next day or the day after.

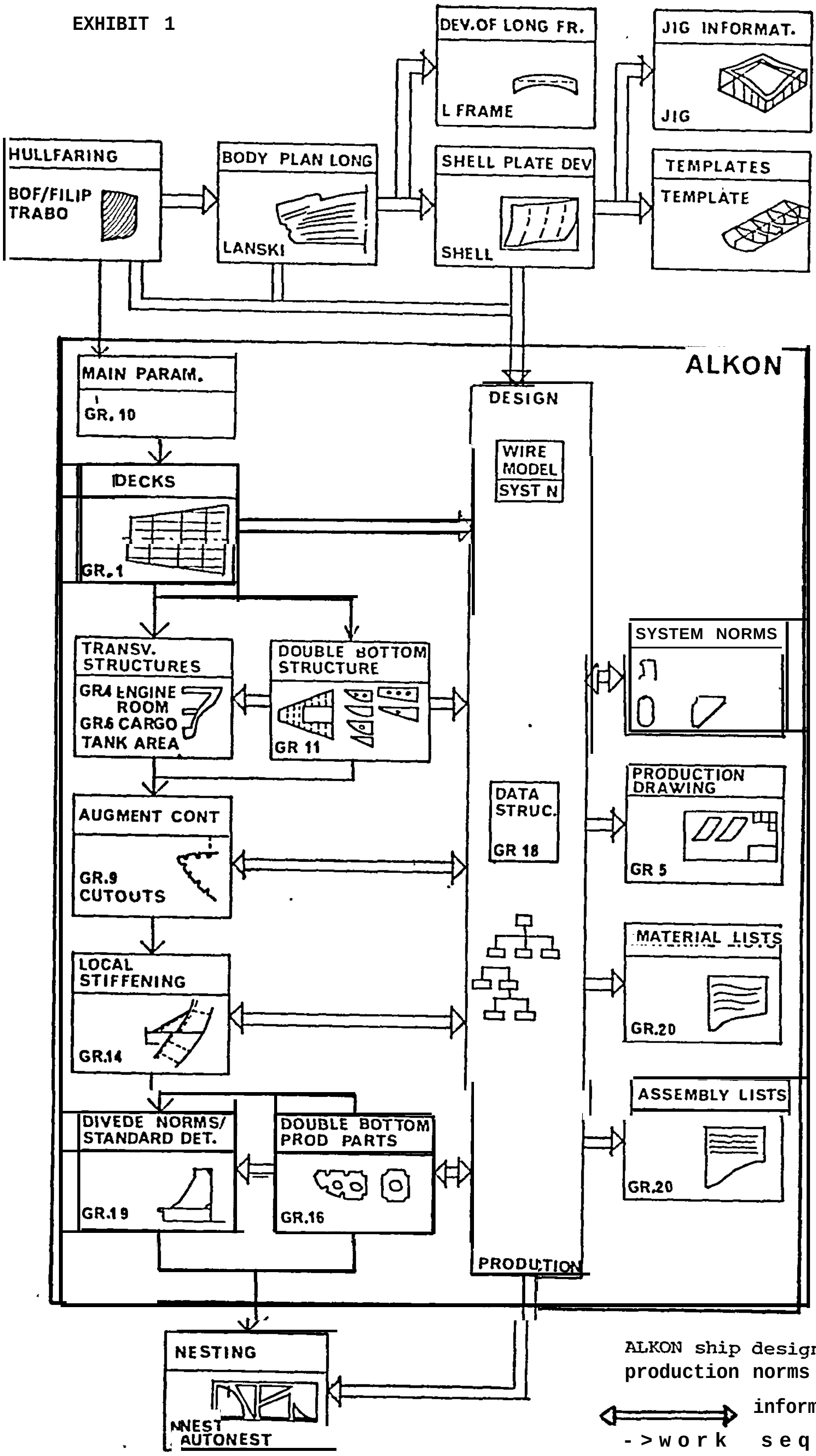
Experience shows that this aspect is neglected by many yard managements, leaving the user in a situation where the software does not really help him. In the worst case it may even turn out to be an obstacle rather than a help, where even the most enthusiastic user will find good reasons to abandon the system. From management point of view, this is bad utilization of invested money.

Design is always a bottleneck in shipbuilding. Lead time is essential, hence the operational environment for AUTOKON-79 in design is even more crucial than for AUTOKON-lofting.

Design lead time is dependent also of factors that are not directly influenced by use of AUTOKON-79: Waiting for approval of owners and authorities, waiting for vendor drawings, slow internal decision making, thinking of design solutions, deliberate design modifications, etc.

AUTOKON-79 certainly reduce routine drafting hours and reduce errors and hours thanks to higher quality of documentation.

EXHIBIT 1



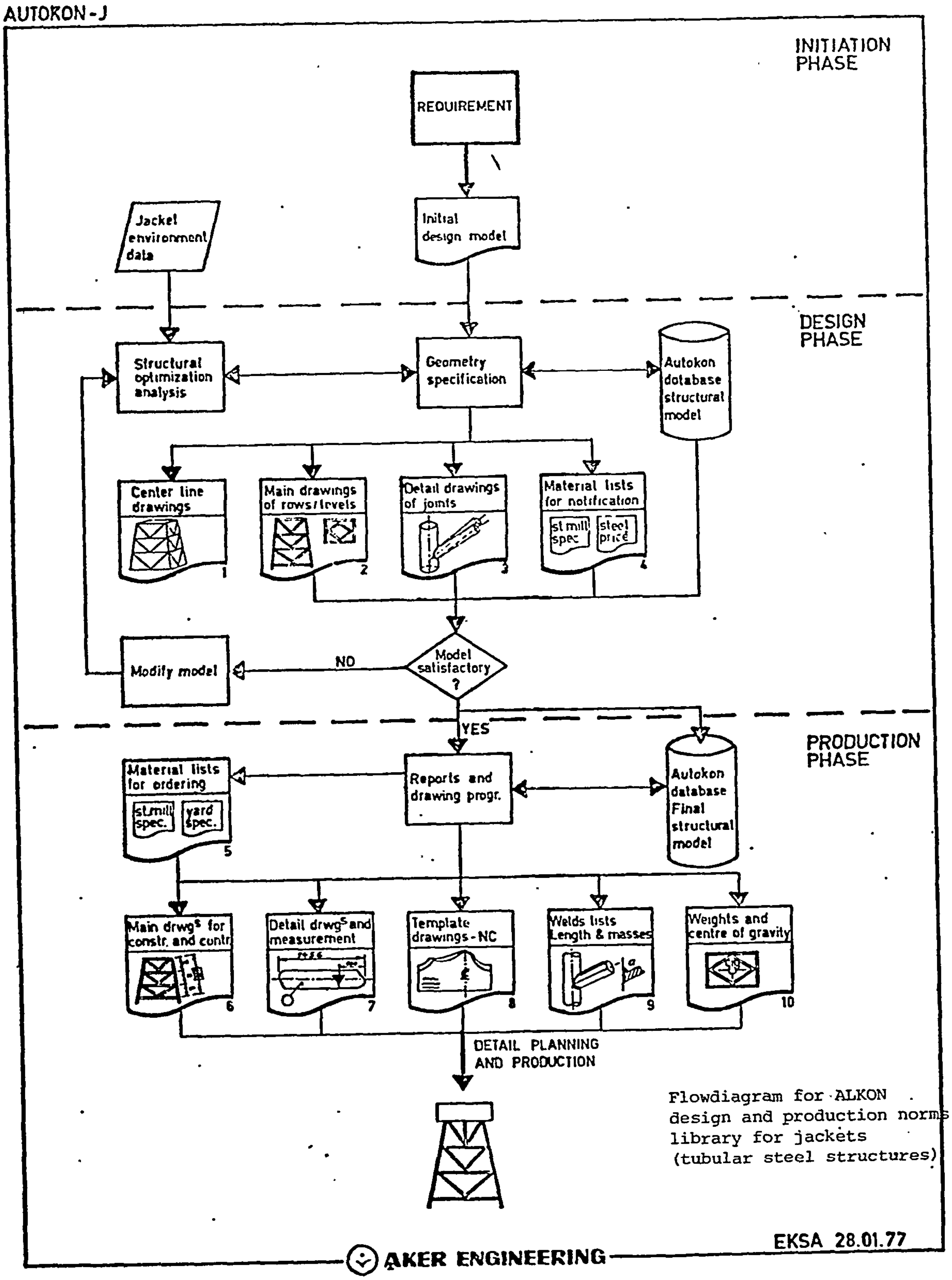
ALKON ship design and production norms library

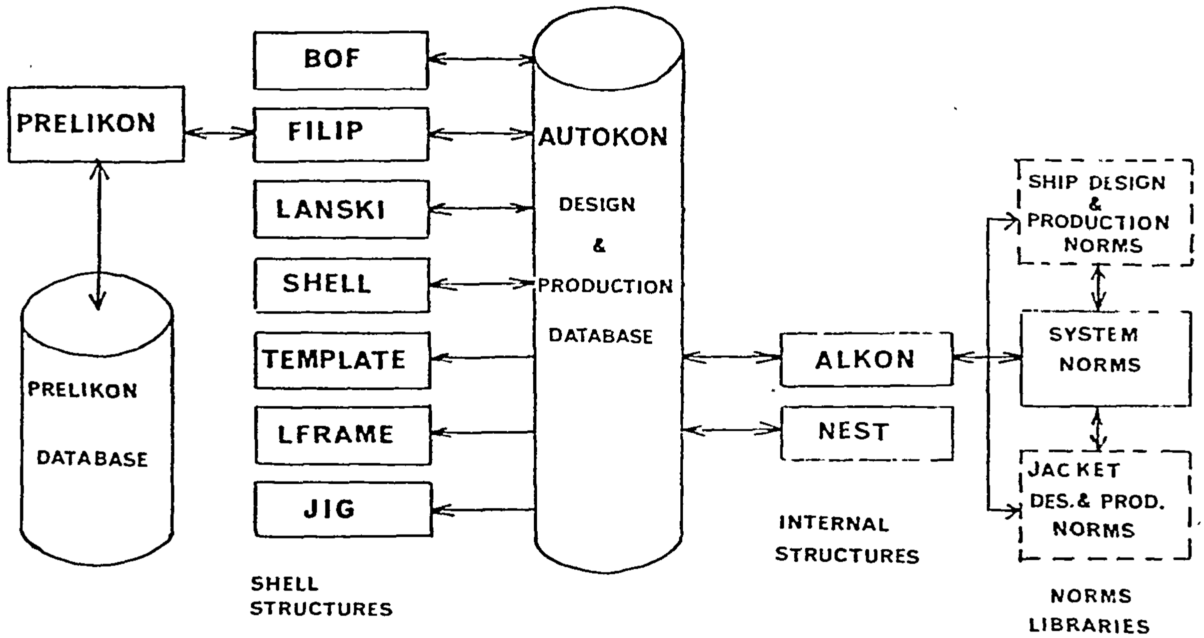
information flolw

->work sequence

COMPUTER AIDED DESIGN - AND WORK PREPARATION FOR JACKETS

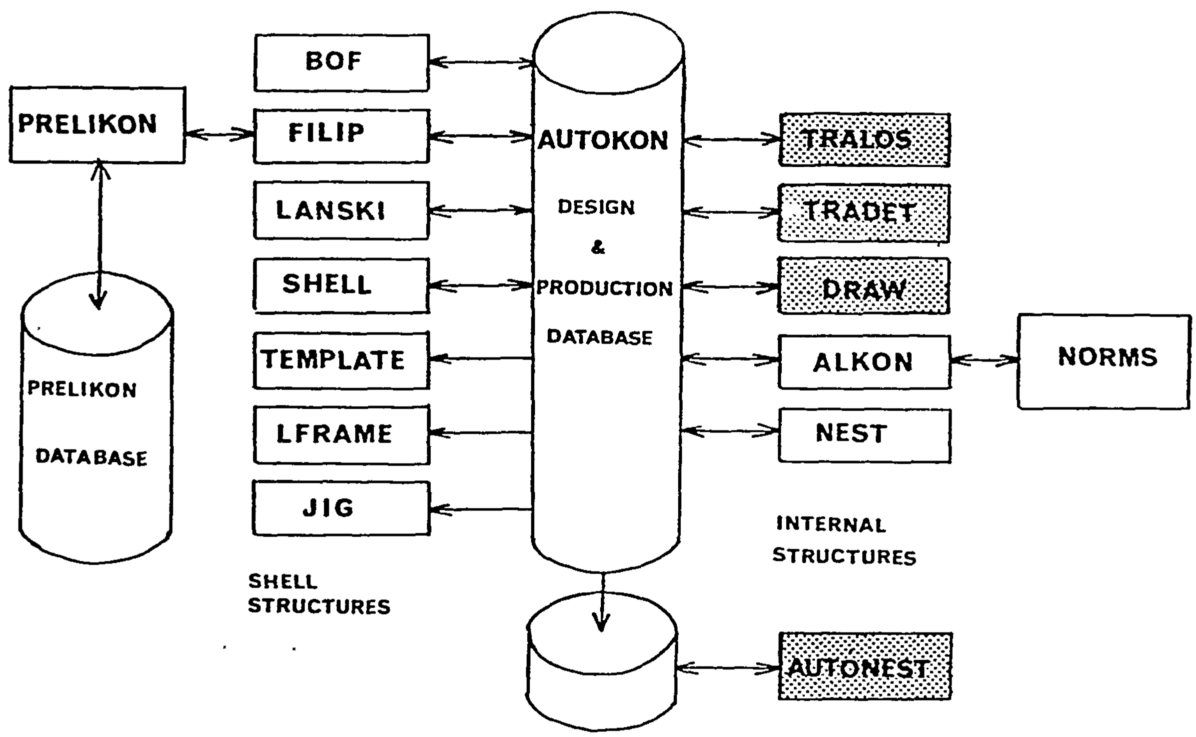
EXHIBIT 2





AUTOKON - 76

EXHIBIT 3



AUTOKON - 79

EXHIBIT 4

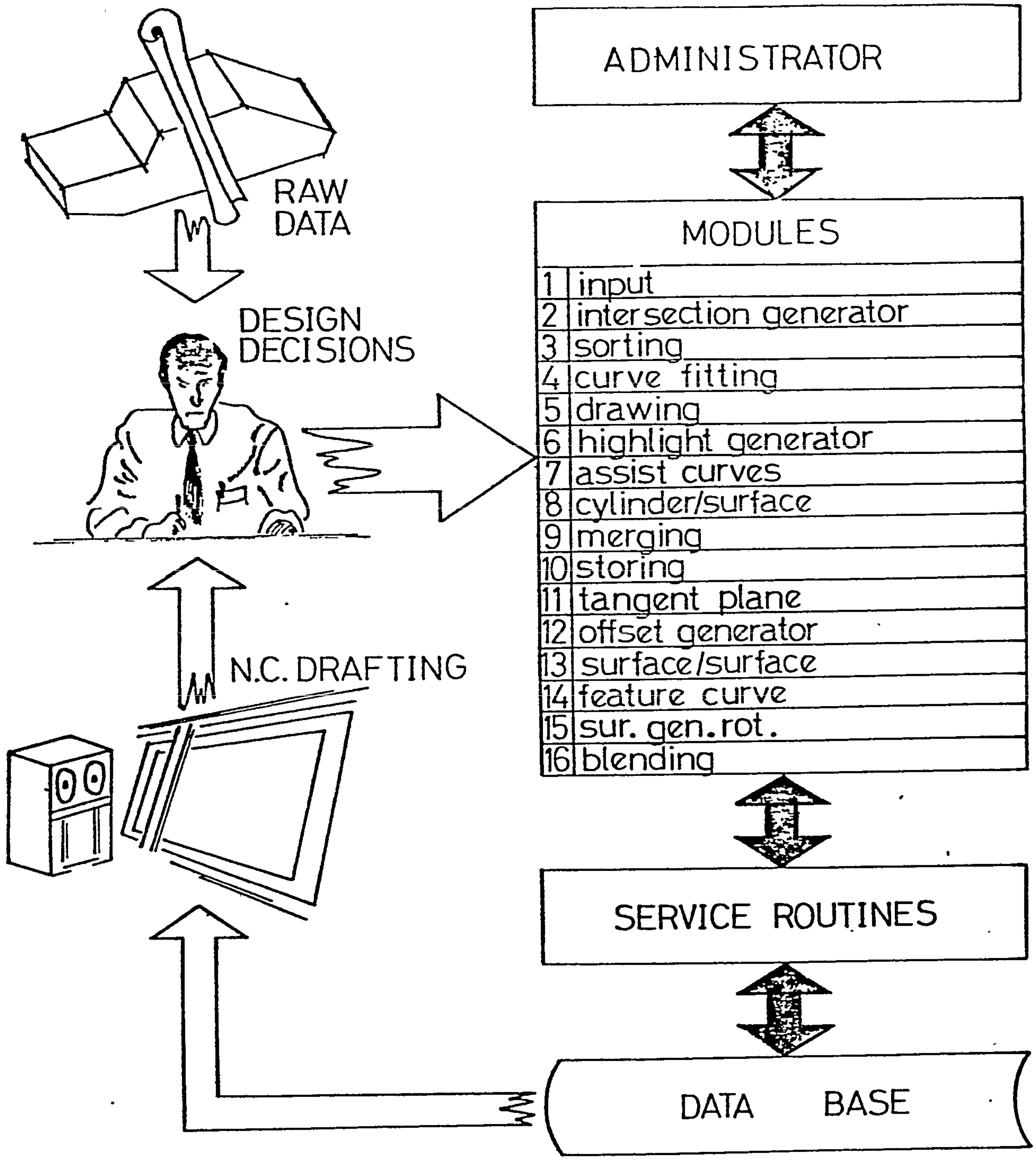
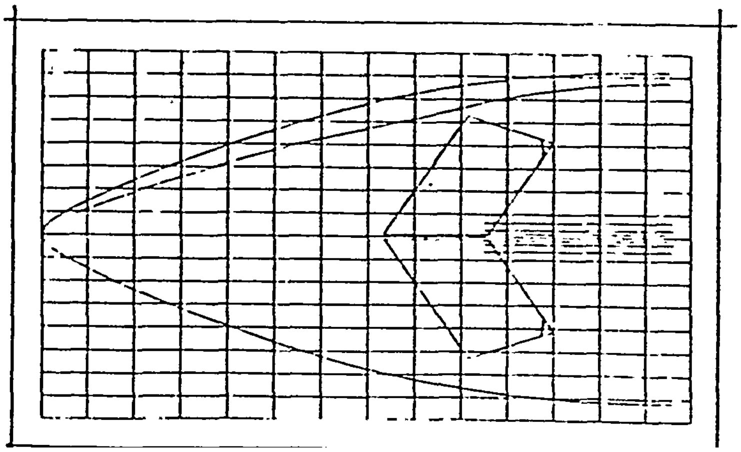
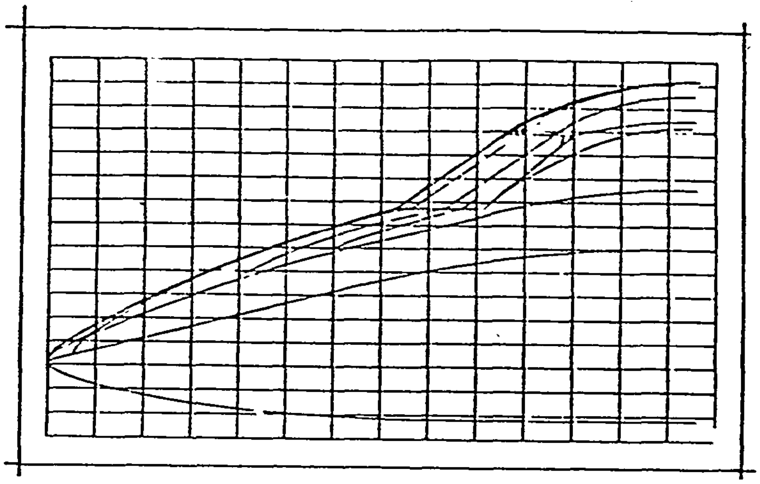


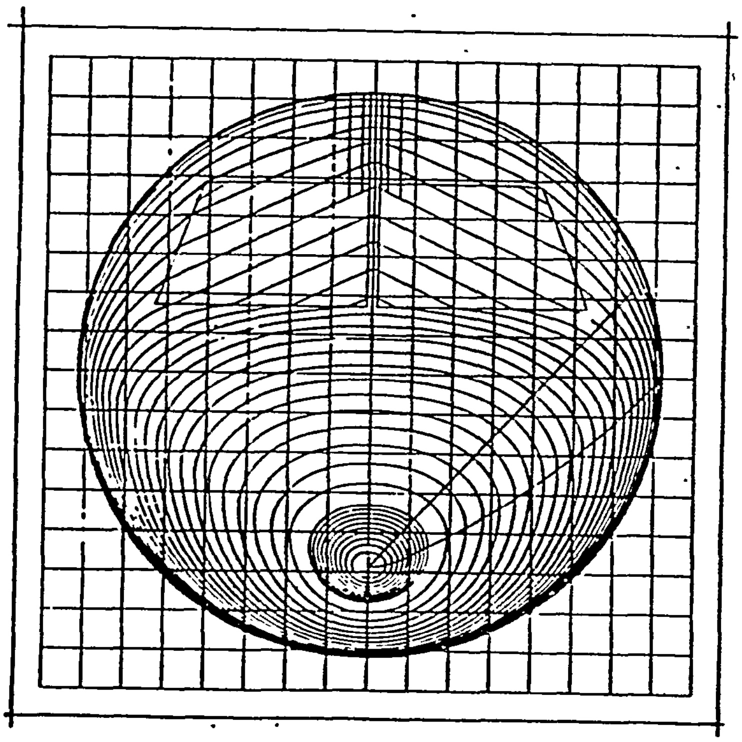
EXHIBIT 5

The BOF surface definition system.
Layout of system functions.

EXHIBIT 6

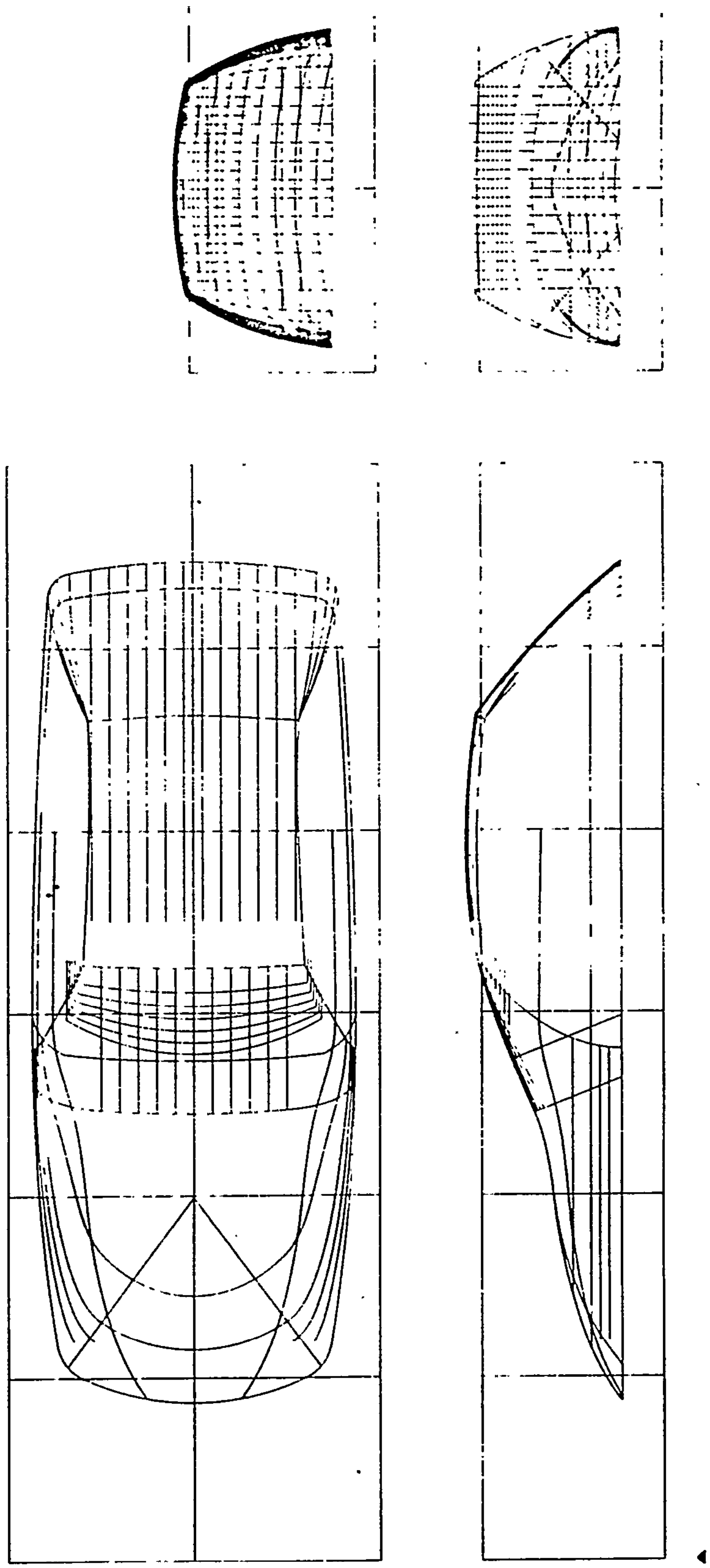




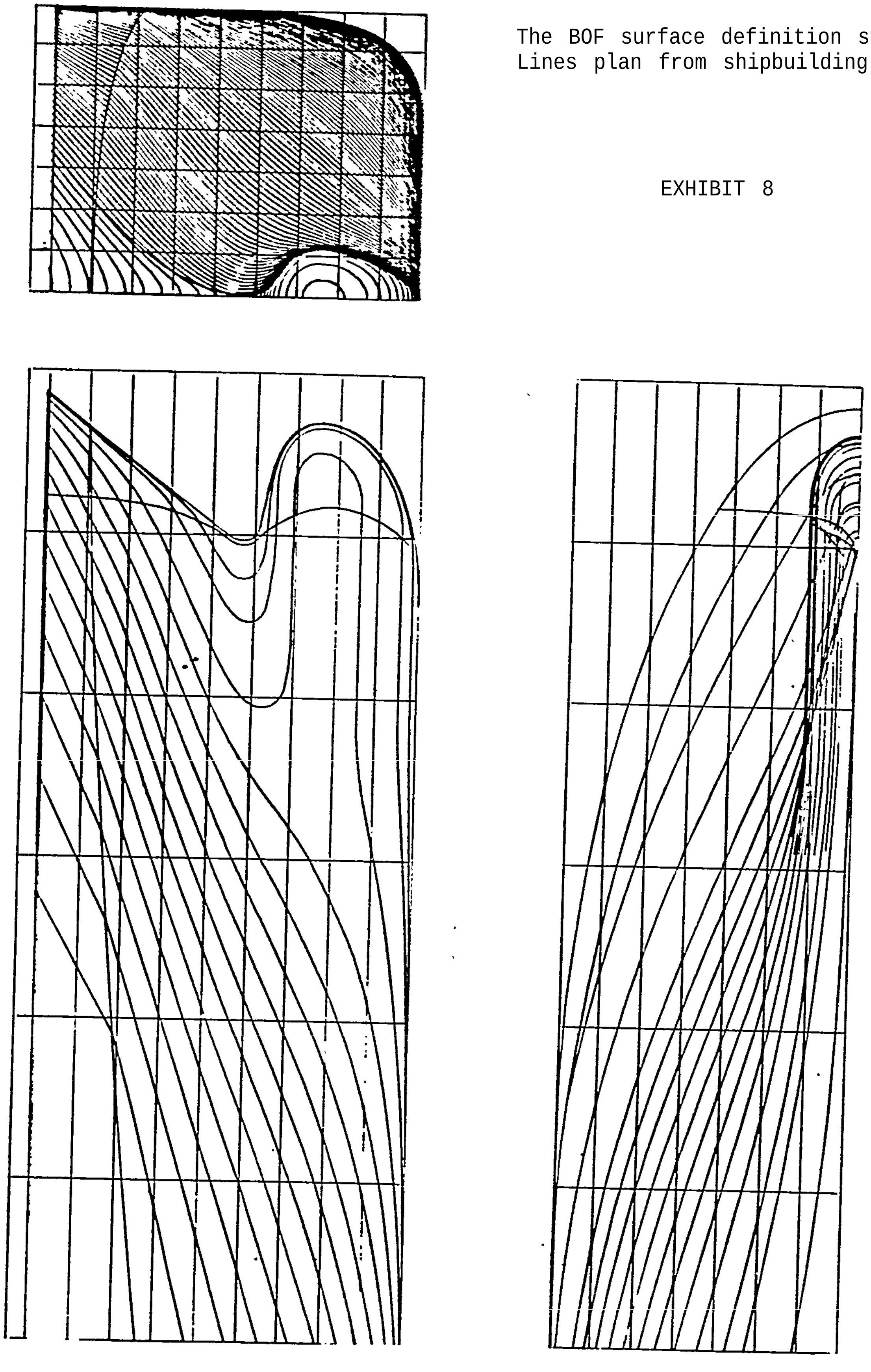


The BOF surface definition system. Extract of results from aircraft application.

EXHIBIT 7



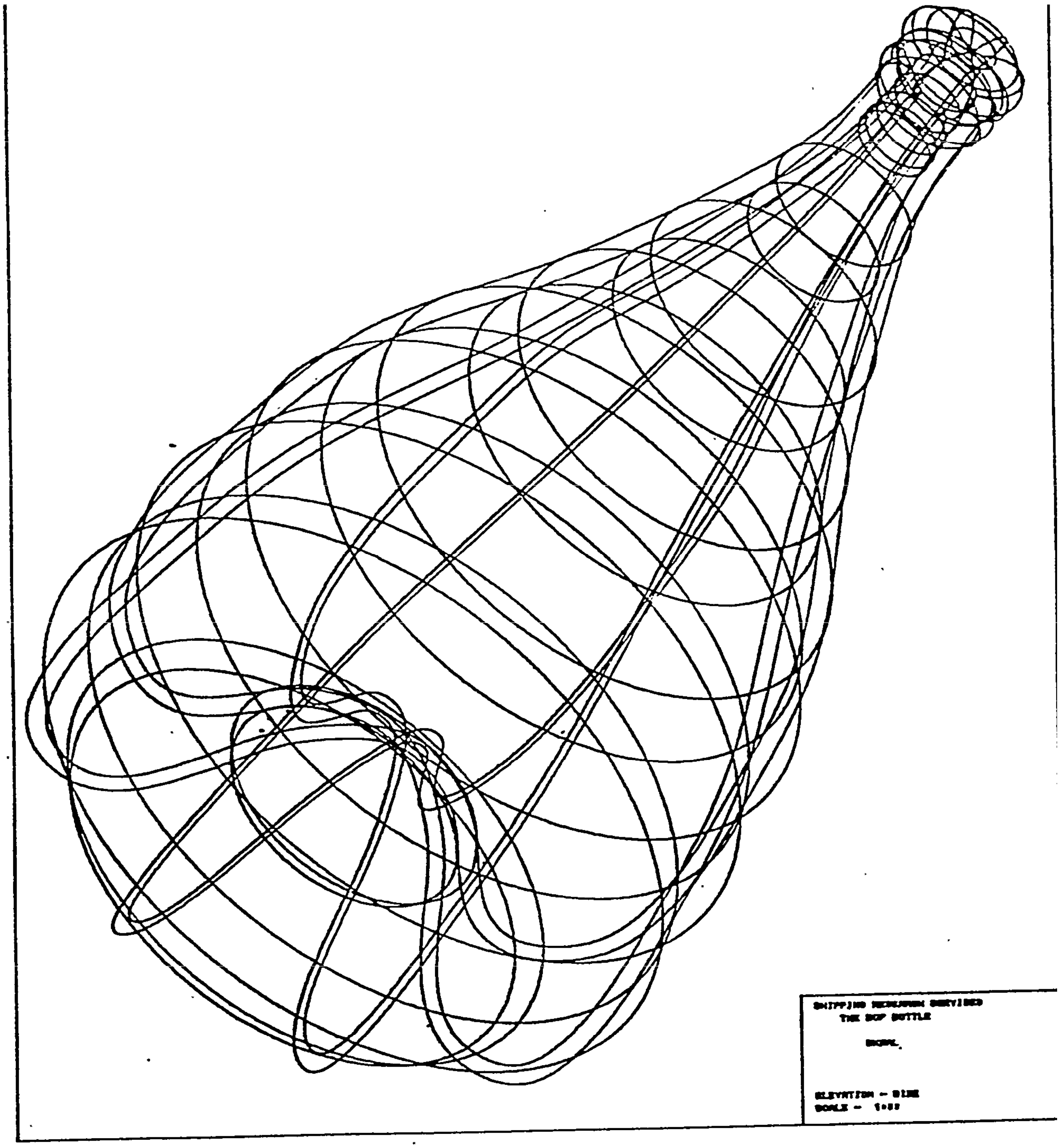
The BOF surface definition system. Extract of results from an automotive application.



The BOF surface definition system.
Lines plan from shipbuilding application.

EXHIBIT 8

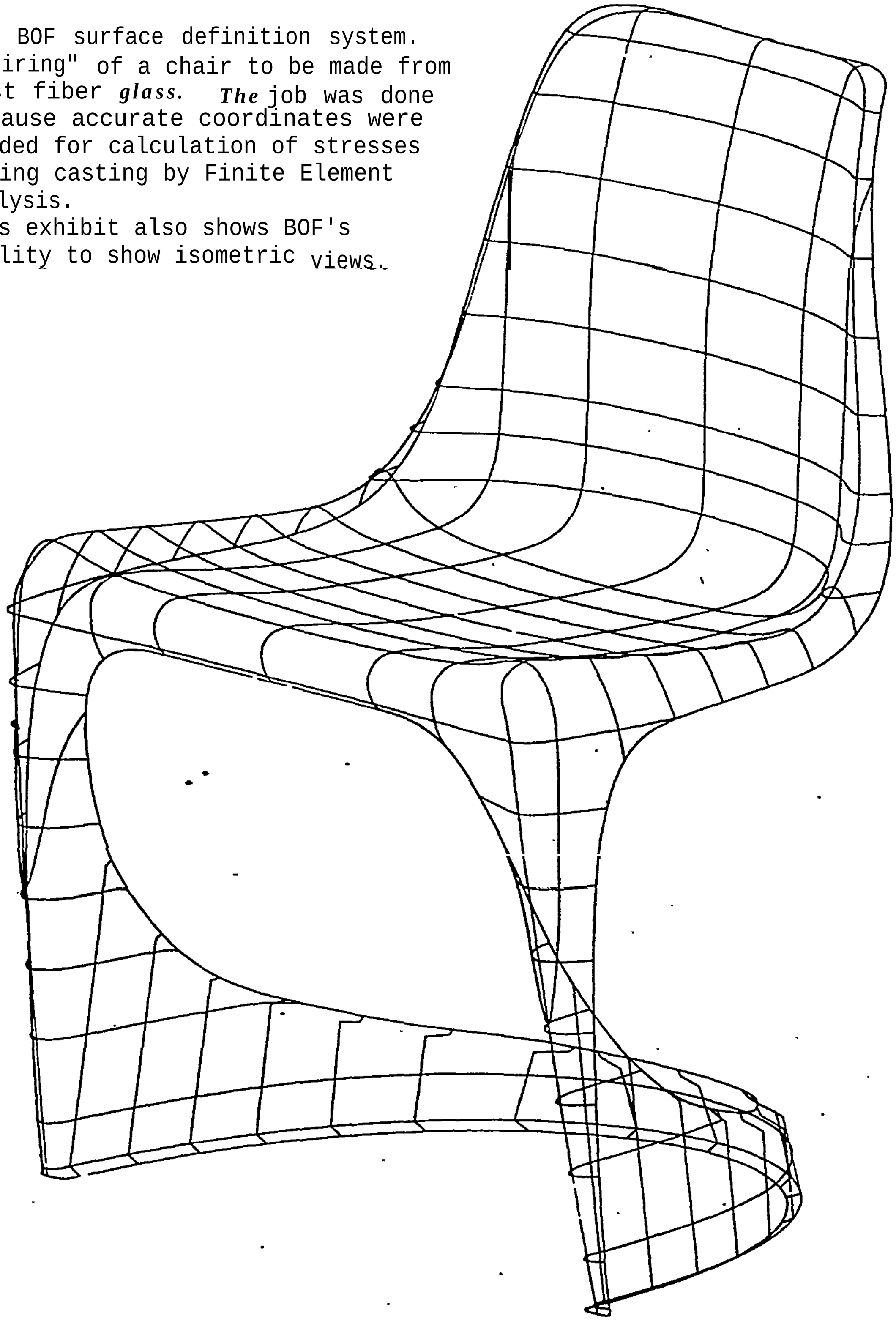
EXHIBIT 9



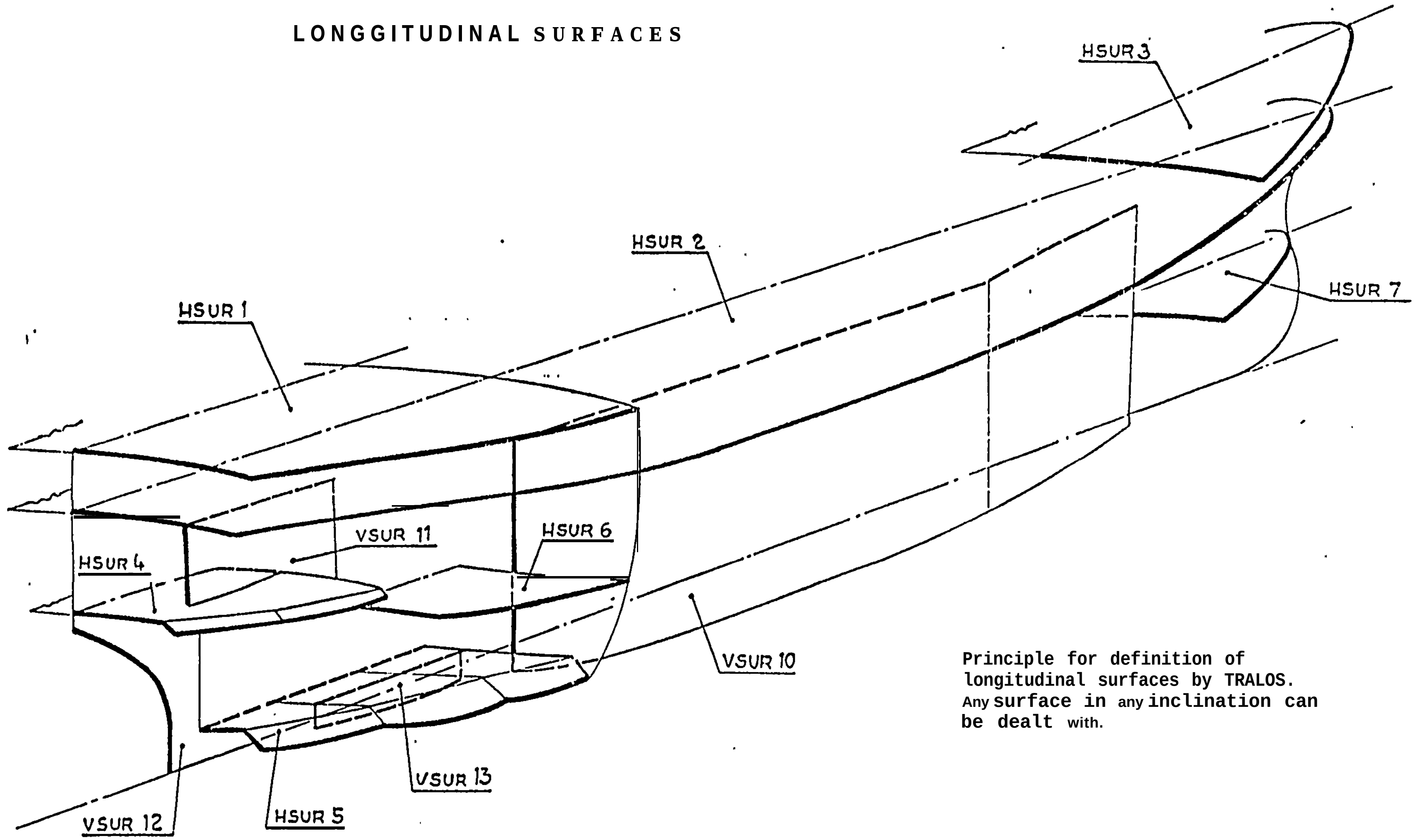
The BOF surface definition system. The bottle surface is defined by rotation of a profile curve.

EXHIBIT 10

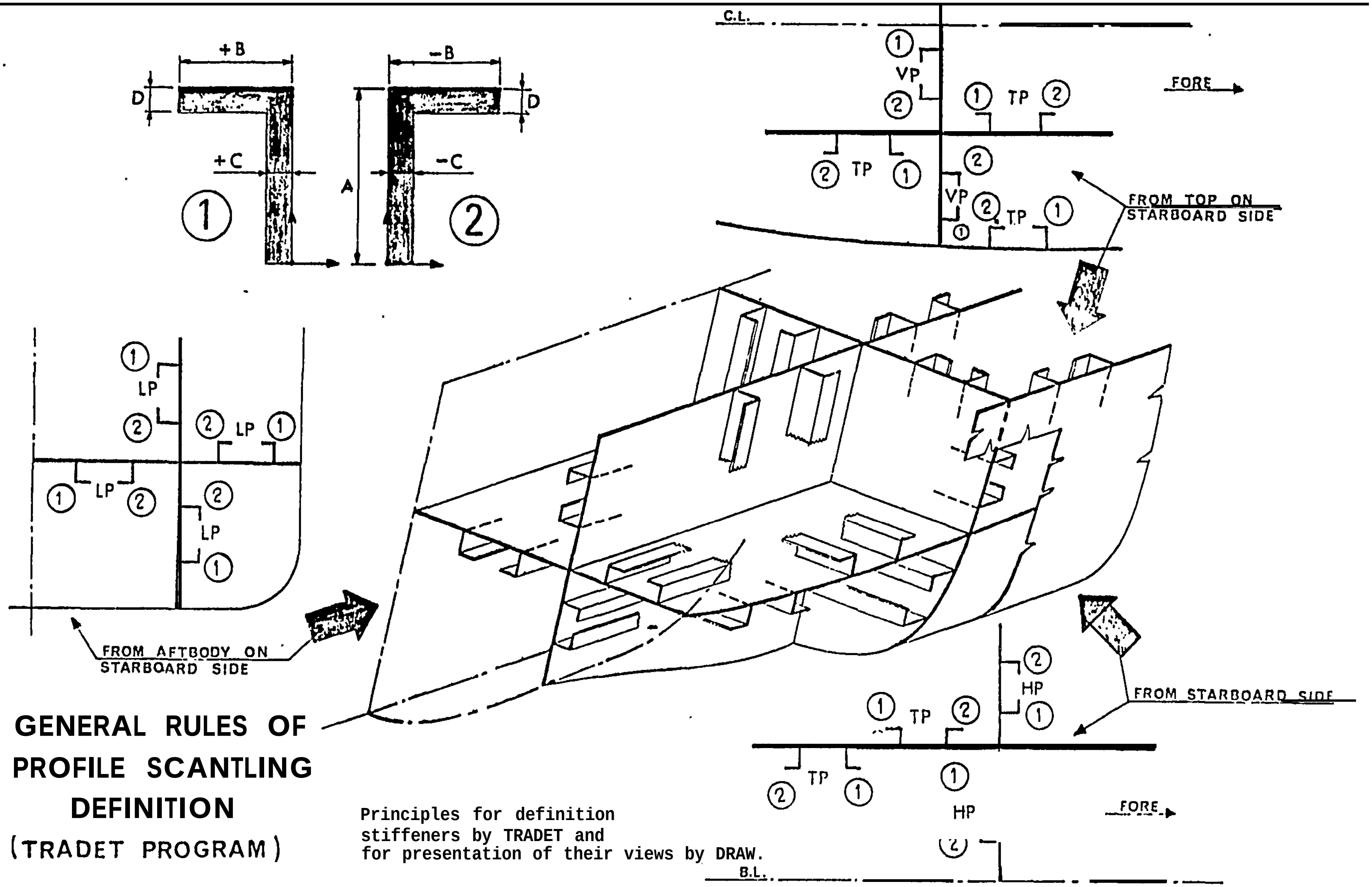
The BOF surface definition system. "Fairing" of a chair to be made from cast fiber glass. The job was done because accurate coordinates were needed for calculation of stresses during casting by Finite Element Analysis.
This exhibit also shows BOF's ability to show isometric views.



LONGGITUDINAL SURFACES



Principle for definition of longitudinal surfaces by TRALOS. Any surface in any inclination can be dealt with.



GENERAL RULES OF PROFILE SCANTLING DEFINITION (TRADET PROGRAM)

Principles for definition stiffeners by TRADET and for presentation of their views by DRAW.

Transverse scantling drawing generated by DRAW based on data loaded by TRALOS and TRADET. Free web frame countours and manholes are based on ALKON data.

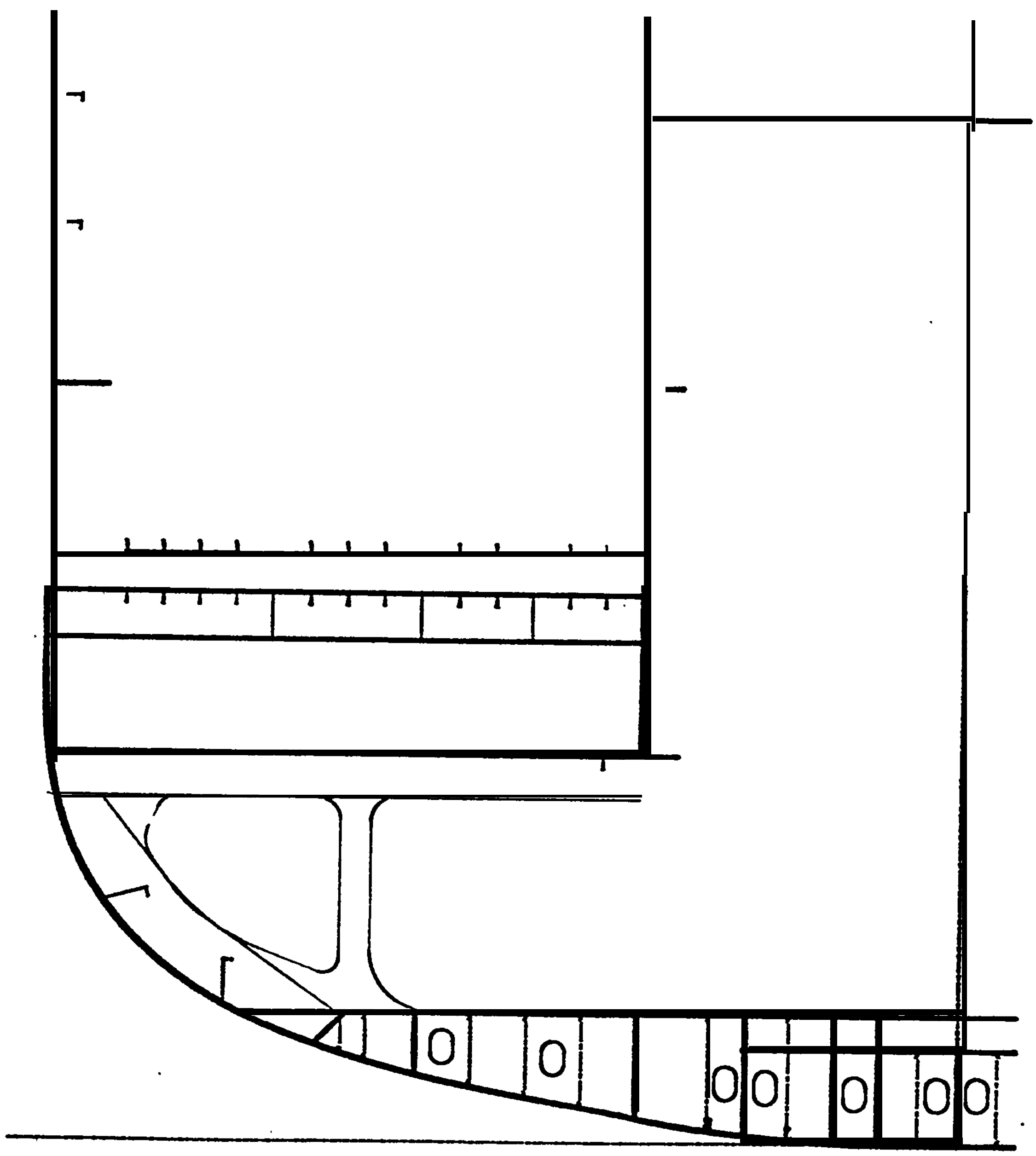


EXHIBIT 14

A transverse bulkhead drawing generated by DRAW for TRALOS and TRADET data, on a Calconep platter, in the scale shown.

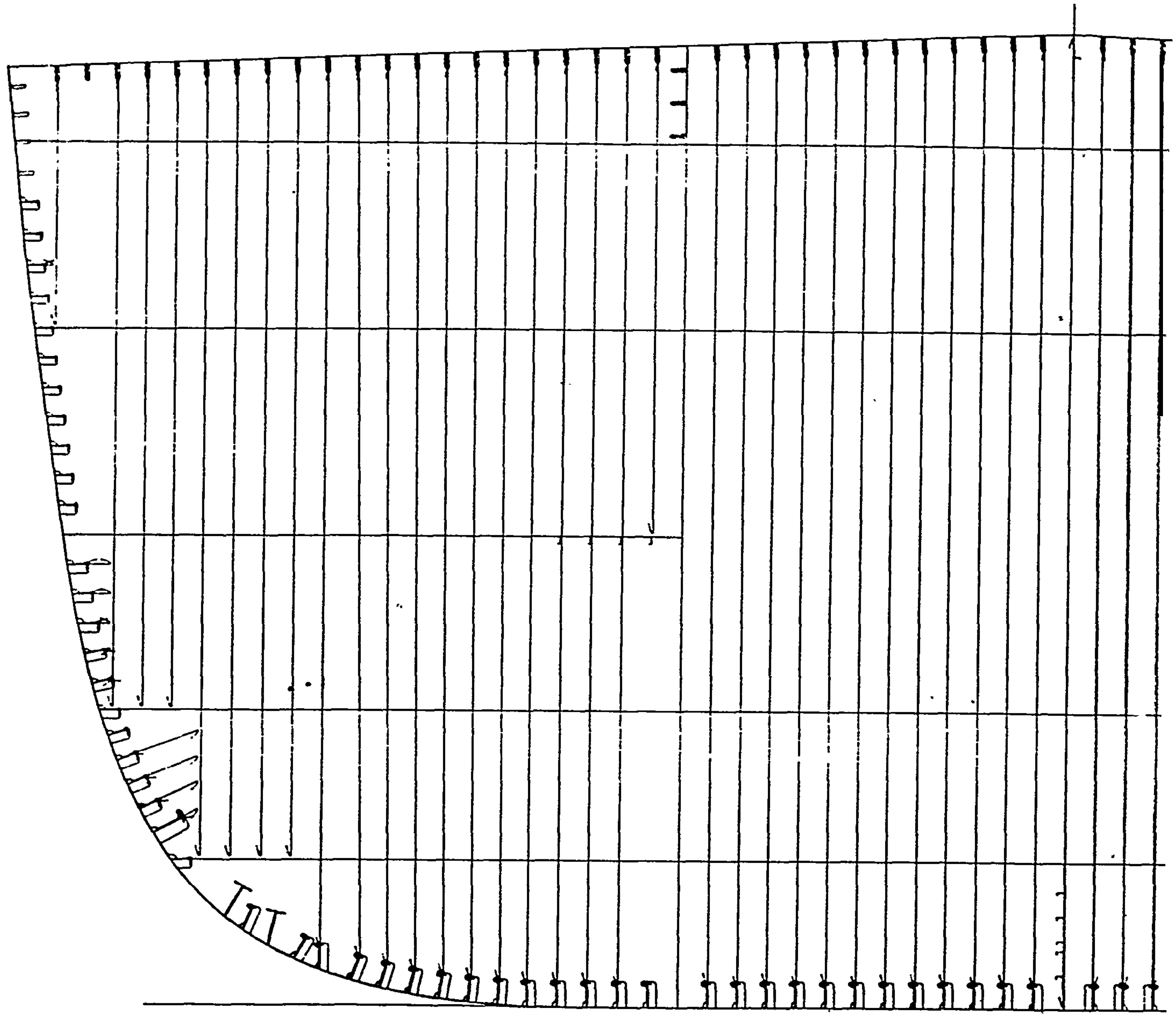
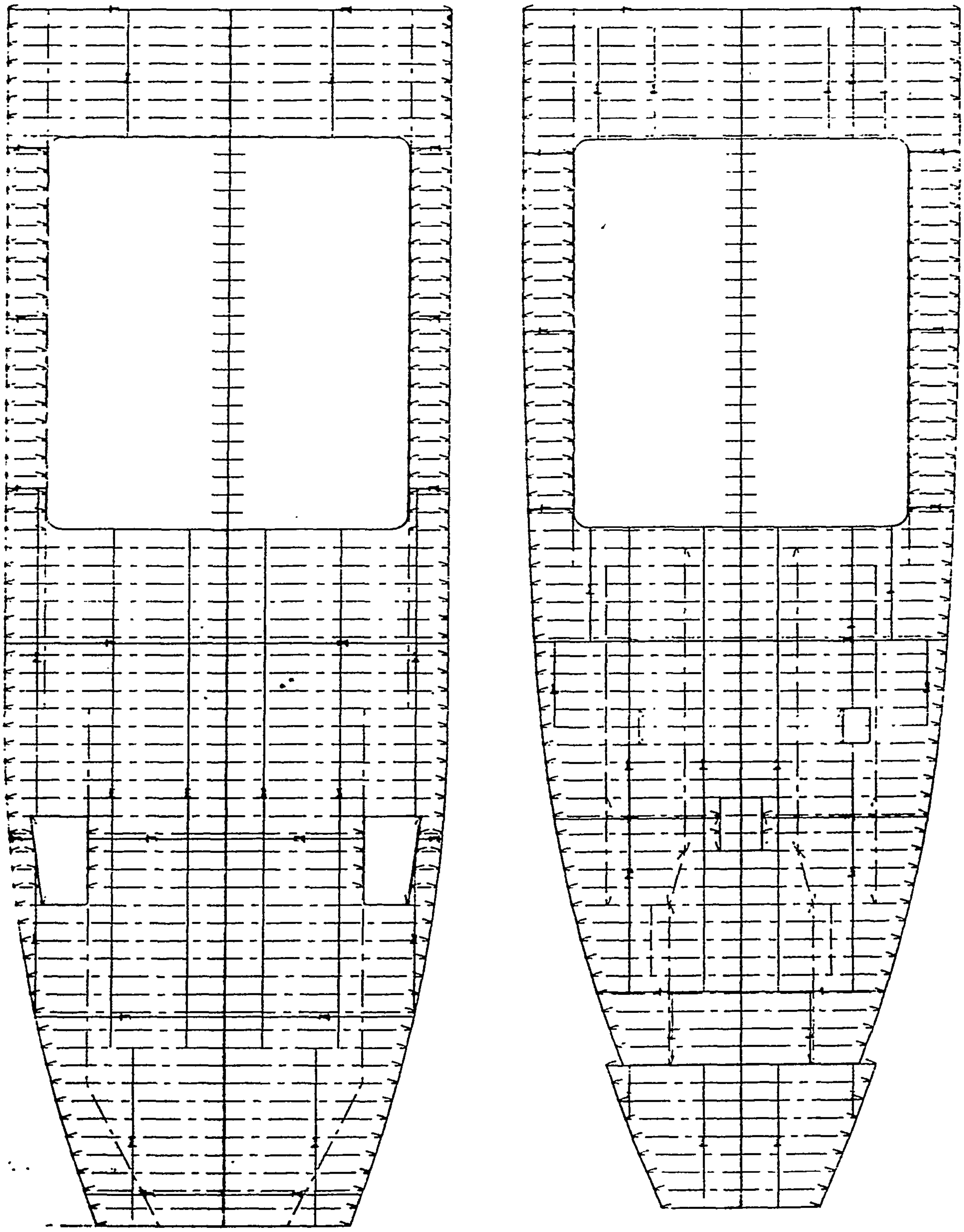


EXHIBIT 15

Structural plans of 2 decks generated by DRAW from TRALOS and TRADET data. All information on the drawings are generated automatically.



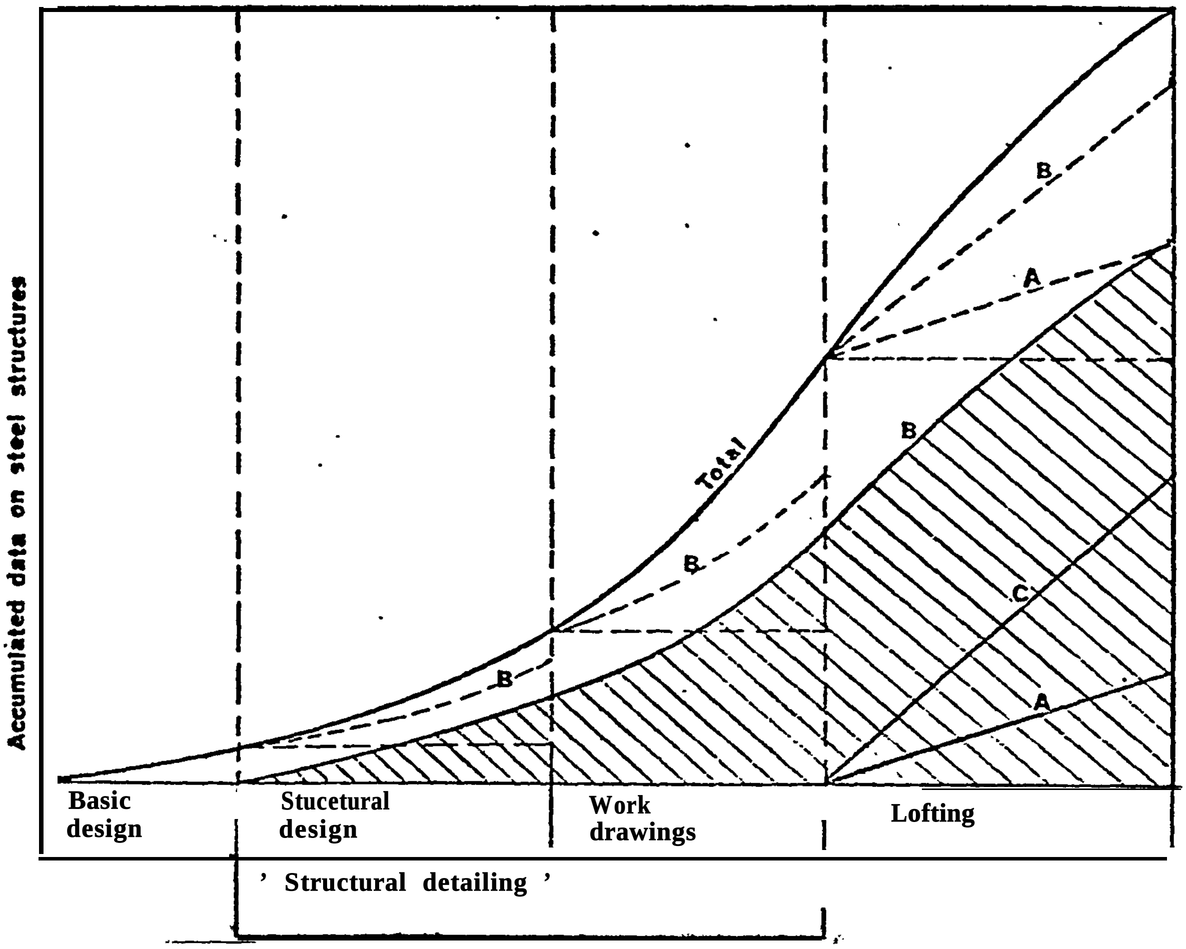


EXHIBIT 16

This diagram (which-has no scale) symbolizes - the.accumulated growth **of** data generated as consequence of an increasing degree of detailing of steel structures down stream from early design to production. Note that in the AUTOKON context "structural detailing" indluces both structural design and work-drawings.

The curve "total" represent the total amount of data to be generated, the other curves the "share" of these data processed by AUTOKON. The dotted lines indicate the extent of computer processing in each "department". The full lines are resulting accumulated curves.

A - using AUTOKON for traditional lofting (part coding and nesting of plates).

B - integrated use of AUTOKON-79 starting as early as possible.

C - using AUTOKON-79 purely for lofting.

The curves may also be regarded to represent: number of drawings and man hours.

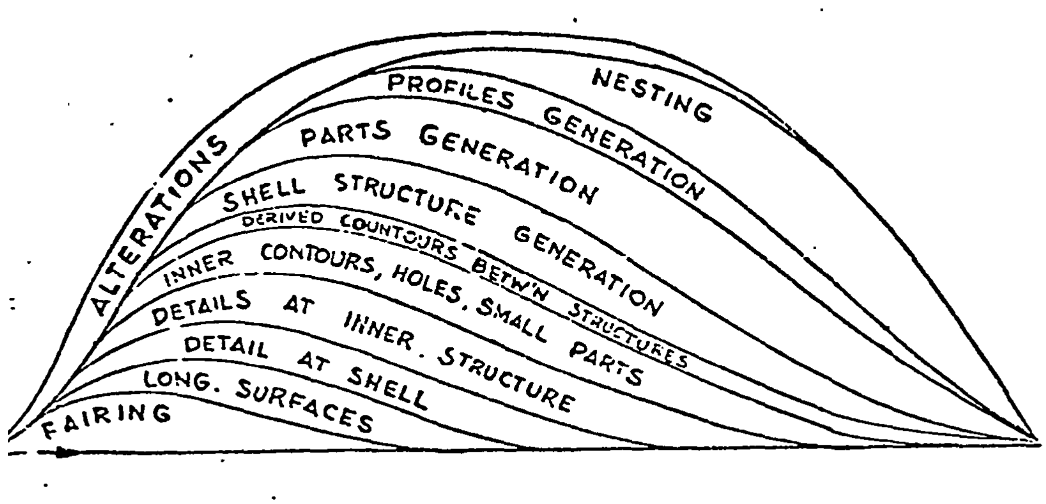


EXHIBIT. 17

This diagram indicates how the various AUTOKON-'79 tasks may be prepared in parallell, irrespective of the fact that the various system modules are processed in a certain sequence. The resulting curve is an expression of work load as function of time.

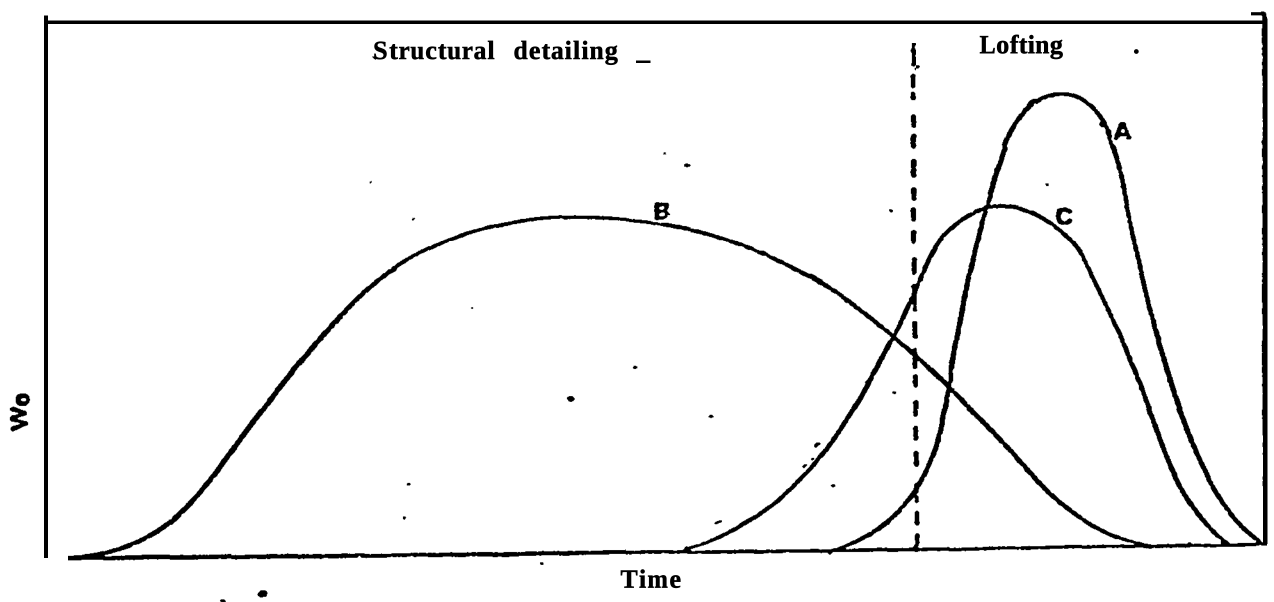


EXHIBIT 18

The curves .A), B) and c) symbolized AUTOKON work load as function bf time, corresponding to the alternative use of AUTOKON as shown in fig. 2. Use of AUTOKON-79 means shift of work, smoothing of peak load and reduction of lead time. The change of pattern from 'A) to B) is striking.

HULSTRX - A CASDAC COMPUTER AID FOR HULL STRUCTURAL CONTRACT DESIGN

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Mr. Klomparens is a naval architect in the Ship Engineering Department. He is currently under contract to support the NAVSEA Surface Ship Structures . Branch in the development of HULSTRX. He has a B.S.E. degree in naval architecture and marine engineering from the University of Michigan, and an M.S. degree in computer science from the Johns Hopkins University.

The views expressed herein are the personal opinions of the author and are not necessarily the official views of the Department of Defense or any department thereof.

INTRODUCTION

This paper is a status report on the development of a computer aided design tool for representing and displaying ship structure. Program Hull Structure (HULSTRX) is being developed for the Navy's (NAVSEA) Surface Ship Structures Branch as a part of the Navy's Computer Aided Design and Construction (CASDAC) project. HULSTRX will aid the Navy primarily during the contract design phase of ship design, which is referred to as level III in the CASDAC project. However, it is expected that HULSTRX will also prove useful to structural designers during preliminary and detailed design studies.

Figure 1 shows how HULSTRX fits into the Navy's ship design process as a part of CASDAC's Hull Subsystem. Reference 1 describes the Hull Subsystem as a computer aid for developing:

a) the hull form,

b) the hull structure, and

c) the weight estimate for naval surface ships.

The Hull Subsystem is primarily intended for use during preliminary and contract design, although many of its elements will also be used during the earlier conceptual design phase. Its products and results serve as input to the Hull Detail Design and Construction Hull Subsystem (HULLDAC). The Hull Subsystem will interface with the Arrangement Subsystem via a Design Geometry Library (DGL).

Individual programs which are included in the Hull Subsystem and are also strongly linked to the structural design process and HULSTRX are:

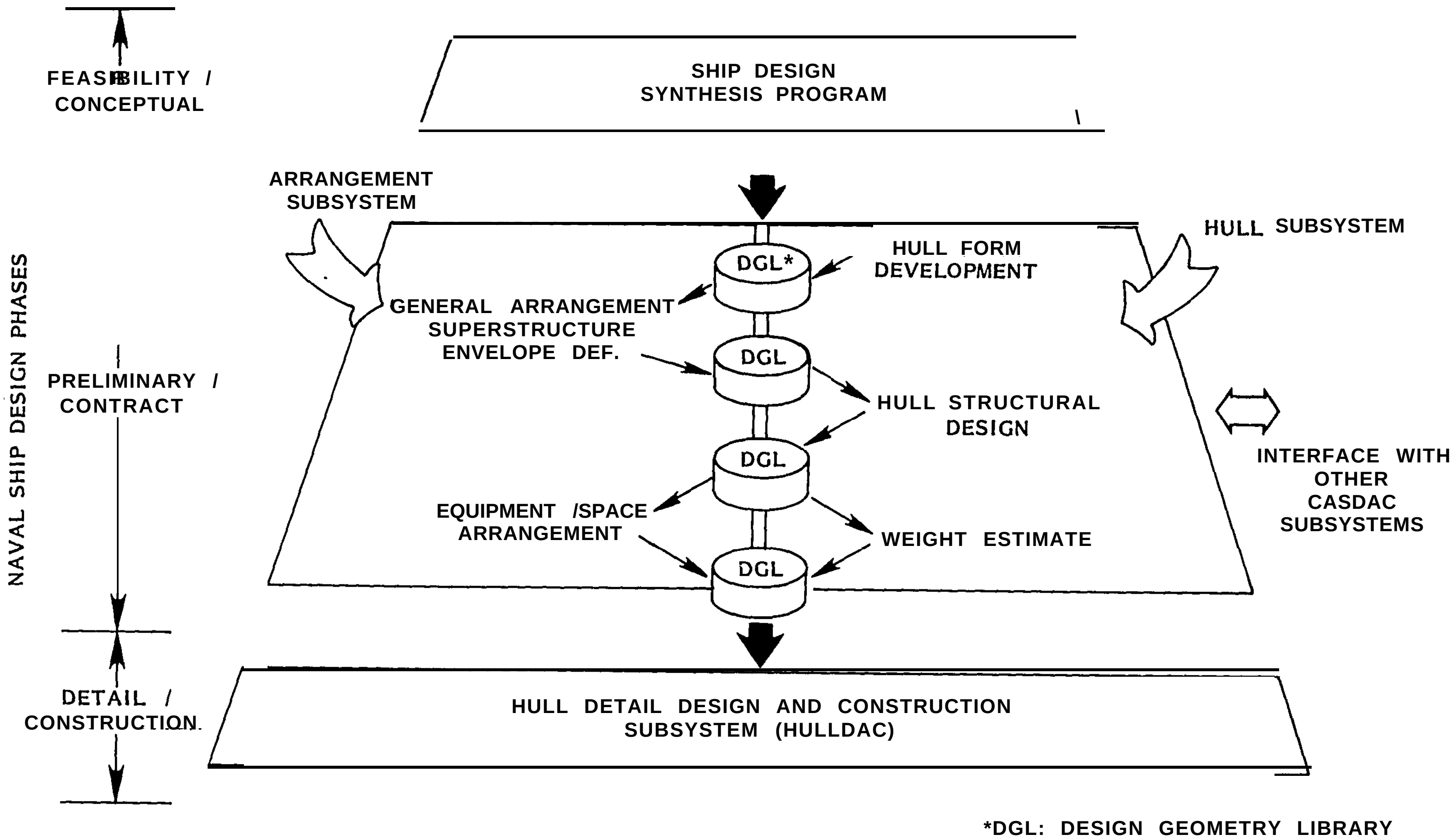

FIGURE 1 - CASDAC HULL SUBSYSTEM OVERVIEW AND SYSTEM INTERFACES

1. HULGEN, a ship hull form generator,
2. HULDEF, a ship hull definition program,
3. SHCP, a ship hull characteristics program,
4. SSDP, a structural synthesis design program, and
5. UPLOT, a general 2-D plotting program.

There are two main purposes of the Structures Branch for developing HULSTRX. The first purpose is to obtain a computer tool to use in generating their contract design deliverables. Design deliverables presently being addressed in HULSTEX are:

1. Drawings of midship section and typical sections,
2. Deck plans for all decks,
3. Expanded shell drawing, and
4. Deckhouse or superstructure drawings.

Other important HULSTRX outputs (not contract deliverables) will include:

1. Longitudinal strength study (this will involve a link to SHCP), and
2. Other structural calculations.

The above contract design deliverables, when produced by hand, necessitate tedious drafting and tabulating efforts. With the assistance of a computer tool, it is expected that there will be a reduction of consistency-type errors, and an increase in engineering effectiveness. Another very important by-product of the use of the computer will be availability of the structural design data in digital form for use in other design disciplines.

The second purpose of the Structures Branch for developing HULSTRX is to let the digital design data become a design deliverable. With HULSTRX, the design data base, and an interface routine, it will be possible to load design packages for detail design, thereby reducing manual data preparation time as well as consistency-type errors. It is hoped that HULSTRX will eventually become available to shipbuilders and others involved in detail design, in the same manner as HULDEF is being used.

The order of funding and development of aspects of HULSTRX are determined by the needs of the Structures Branch as well as the CASDAC office. In a paper presented at the June 1978 REAPS Technical Symposium, Tom Gallagher of the Structures Branch presented (Reference 2) his ideas on how a design agent can better assist shipbuilders. HULSTRX is the implementation of some of these ideas.

HULSTRX is being developed in a piece-wise fashion. There are also other studies occurring simultaneously which will strongly effect the development of HULSTRX. Specifically, the structure of the design geometry library (DGL) and the interface with the Arrangements Subsystem. Development of HULSTRX is proceeding with the understanding that changes will be made during development and use, a condition certainly not unique to HULSTRX. For example, there are plans to modify the Ship Hull Characteristics Program (SHCP), one of the most established programs in the Hull Subsystem. One of the important reasons for continual development of finished programs is that the programs themselves change the design process in unpredicted ways. This paper addresses the current status of HULSTRX with the understanding that changes are expected and desired.

HULSTRX DEVELOPMENT STATUS

HULSTRX is a modular program which will allow structural designers to develop and then use computerized files of structural arrangement data, such as stiffener and plate-edge traces, and structural member data, such as scantling and material information. The program will employ many of the concepts implemented in the HULDEF program. The three most important concepts borrowed from HULDEF are:

1. The program will initially be used in a batch mode.

2. The HULDEF file structure and format will be used *in* representing structural arrangement data.

3. HULDEF's parametric spline is being used to represent structural traces (3-D lines).

Many of HULDEF's routines that deal with the lines file and manipulate lines are being used in HULSTRX, and are described in References 3 and 4. Details of HULSTRX current development are presented below as inputs, structural trace processing (mapping methodology), and outputs to the program. Some of this material has been presented in Reference 5.

HULSTRX will accept design data from the structural designer in the following ways:

1. Design Geometry Library

The primary input to the structural design effort and to HULSTRX is the geometrical shape of the hull and the major hull subdivisions as represented by surface intersections. The DGL is (currently) first established by NAVSEA's Hull Form Branch, resulting in two surfaces, shell starboard snd shell port.

Major subdivision data will then be added to the DGL in the form of surface intersection lines. Surface intersection lines bounding a surface will be used to initiate the process of describing other surfaces, such as bulkheads, longitudinal bulkheads, and

decks. The interface between the Hull and Arrangements Subsystems, the DGL, is currently under development, so the content and form of the DGL as input to HULSTRX is tentative. Figure 2 shows schematically the geometric hull shape and subdivision data that will be needed as input to HULSTRX.

2. Structural Design Data

HULSTRX will not directly deal with ship structural synthesis, but will represent and aid in the display of the structural design. The other major input to HULSTRX is the structural arrangement and scantling data generated by the structural designers.

The U.S. Navy uses a computer aided structural design tool called the Structural Synthesis Design program (SSDP) to develop longitudinal structure at a number of ship cross sections. SSDP, Reference 6, allows structural engineers to input the geometry of a particular transverse section consisting of major longitudinal surfaces such as shell, decks, platforms, and longitudinal bulkheads, along with loading conditions and longitudinal stiffener spacing (ranges). The program will design a section with the lowest practical weight, and will provide scantlings and structure that will comply with current U.S. Navy design criteria. Further development of SSDP is being considered to allow for design to American Bureau of Shipping standards.

During HULSTRX development, a digital interface will be developed between SSDP and HULSTRX. Data from the numerous section designs, consisting of plate thicknesses, stiffener scantlings (or stiffener size code), and stiffener spacing, will be passed to HULSTRX. This interface will relieve-designers from tedious data preparation tasks.

With the structural design data from SSDP available to HULSTRX, the designers will then immediately be able to display the design

SHIP, DATE

SHOOOS (SHELL STARBOARD)
CLOOO CENTERLINE
SHELL GEOMETRY LINES
BLANK(')

SURFACE NAME

TRACES IN END-POINT TANGENT FORM (HULDEF'S FORMAT)

SHOOOP (SHELL PORT)
SAME FORMAT AS FOR SHELL STARBOARD
BLANK

SURFACE NAME

TRACES IN END-POINT TANGENT FORM (HULDEF'S FORMAT)

DECK 1

DECK 2(2)

PLATFORMS

FLATS

TRANSVERSE BULKHEADS

LONGITUDINAL BULKHEADS

GIRDERS

NOTE :
(1) BLANK TRACE NAME INDICATES END OF SHELL SURFACE IN HULDEF
(2) EACH DECK, OR ANY OTHER CATEGORY OF SURFACE, MAY BE REPRESENTED AS A INDEPENDENT SURFACE SUB-FILE.

FIGURE 2 - DESIGN GEOMETRY LIBRARY DATA REQUIRED AS INPUT TO HULSTRX

and check for structural longitudinal continuity with structural body plan and shell expansion drawings.

3. Manually Generated Structural Design Data

Although most of the structural design data will be passed to HULSTRX via the SSDP interface, substantial changes and additions to the structural design will have to be made manually. For example, some of the longitudinal stiffeners formed by stringing the SSDP data together from the individual section designs must be dropped off at a specific point. Manually generated design data will be input using numerous concise formats. Examples of the ways geometric data for structural traces will be submitted include:

1. Single lines as defined by numerous coordinate pairs (the program will calculate the third coordinate forming a triplet),
2. Longitudinal equally spaced lines,
3. Reflected (mirror image) lines.

Development of HULSTRX to this point has included establishing how the structural arrangement data from the SSDP will be accurately mapped onto the various ship surfaces. This mapping process will be described for the shell surface.

SSDP specifies how stiffeners are positioned on a segment of the shell surface, at a particular ship cross section, by simply defining the stiffener spacing within that shell segment. Shell segments are defined by the user. For one stiffener, the girth at that section can be calculated, and With the section's longitudinal position expressed as an x-value, a point on the stiffener is uniquely defined as (girth,x), and can easily be converted to a coordinate triple. Other points defining the position of this stiffener

are obtained from SSDP output at different sections. If these points are then splined forming a longitudinal stiffener trace, points on the trace between definition points may not fall on the ship's molded surface. The method developed for mapping a trace onto the shell surface employes many of the procedures and routines in the HULDEF program. Before describing the procedure, it is necessary to describe the means for defining the shell geometry.

Shell surface geometry is defined primarily by longitudinal girth-fraction lines. A girth-fraction line is a longitudinal line formed by splining points on sections, where the point on each section is located at a fraction of the girth on that section. Alternatively, the shell surface geometry can be defined with other types of longitudinal lines, such as waterlines.

The hull designer uses HULDEF to fair a family of longitudinal lines. These longitudinal shell definition lines generally consist of about nine girth-fraction lines, a deck-at-edge line; stem line, transom line, and other lines that help specify knuckles or flat plate areas in the hull. For the purposes of this discussion, these lines will be referred to as the longitudinal shell definition lines, or L-lines.

Various options in HULDEF allow the hull designer to create section, waterline, buttock, and diagonal lines on the shell surface. Sections are created by intersecting the L-lines with an x-plane: find all L-line intersections with an x-plane, and spline the intersection points. These transverse cuts, stations or frames, can then be plotted and/or stored on the DGL, in the shell surface. The number of stations or frames stored on the DGL is user-dependent. These stations or frames will be referred to as the transverse shell lines, or T-lines. The hull designer usually specifies enough stations for a plot so that a visual check of the lines fairness can be made.

'When other longitudinal lines, such as waterlines and buttocks are to be generated (for plotting or storing), HULDEF first creates a temporary file of T-lines. The number of transverse cuts of the L-lines made to create this temporary file of T-lines is user-dependent. A T-line is made at every station or frame specified by the user, but when stations are specified (as opposed to frames), this list is automatically supplemented by the program to include T-lines at l/4, l/2, and 3/4 station spacing. Once this temporary T-line file is created, waterlines, buttocks, and diagonals (all considered longitudinal lines) can be created in a manner similar to that of transverse lines. The temporary file of T-lines is cut by the appropriate plane forming the points of intersection. Some of the L-lines, control lines and form lines, are also cut by this plane and are added to the list of T-line intersections. All of the intersections are then splined and the line is plotted and/or filed into the DGL shell surface.

When a transverse line of the shell surface is needed, the longitudinal shell geometry lines (L-lines) are cut. When a longitudinal line is needed, a temporary transverse lines file is first created by cutting the L-lines, and then the T-lines are cut to form the new longitudinal line.

Together, the L-lines and the temporary T-lines form a grid of lines over the shell surface which completely defines the shape of the shell surface. The only information needed to generate this grid is the original L-lines, and a list of x-values of station or frame positions. This information, together with the parametric spline and line-cutting algorithms, provides for a concise and accurate means of representing the shell surface.

Structural traces to be mapped onto the hull surface will be considered as one of two types:

- Straight traces - lines that are straight when viewed in at least one of the three Primary planes (x-plane, y-plane, or z-plane). The program will recognize structural traces as being straight when the input for the trace consists of exactly two coordinate pairs: two (X,Y) pairs, two (x,z) pairs, or two (x, girth) pairs.
- Curved traces - lines that are defined by more than two coordinate pairs.

A straight or curved trace to be mapped onto the shell surface will either be considered a longitudinal trace or a transverse trace according to the following rules:

- For (x,y) input pairs, if $\left|\frac{\Delta x}{\Delta y}\right| \leq 0.5$, line is transverse

  if $\left|\frac{\Delta x}{\Delta y}\right| > 0.5$, line is longitudinal

- For (x,z) input pairs, if $\left|\frac{\Delta x}{\Delta z}\right| \leq 0.5$, line is transverse

  if $\left|\frac{\Delta x}{\Delta z}\right| > 0.5$, line is longitudinal

The mapping routine will be initiated by creating a temporary file of T-lines as previously described. The x-positions for the transverse cut of the L-lines will be determined by reading the positions of the stations or frames already on the DGL shell surface. If station lines are on the shell surface, as opposed to frames, the x-value list will be supplemented with the 1/4, 1/2, and 3/4 station x-values.

Once the temporary file (stored on secondary, disk, memory) is established, each structural trace is mapped onto the shell surface, one line at a time. If an error is encountered during the processing, an error message is written via the line printer and processing for the next trace started.

If a straight line is transverse, all the L-lines will be cut, forming point intersections. These points will then be splined, and the splined line will be "snipped" off at its endpoints.

If the straight line is longitudinal, the T-lines will be cut by a plane. Five T-lines forward and aft of the line endpoints will be cut, if available, assuring that the line is precisely mapped onto the shell surface. The resulting splined line will then be snipped to the appropriate length, and stored.

For curved lines, the mapping procedure is quite different. If the curved (input) structural trace is transverse, a longitudinal cut of the T-lines will be needed, using either a y or z plane, to form a temporary longitudinal line, a major line. The new major line will be intersected with the input line to produce an intersection containing the third coordinate of the input point. A temporary longitudinal line will be required for each input point in the trace.

The next step for a curved, transverse line will be to find the coordinate triples of any of the original L-lines within the endpoints of the trace. Coordinate triples (approximately four) will also be required beyond the endpoints of the trace to insure that the ends of the trace are precisely mapped onto the shell surface. When all of the triples are found, the line will be splined, snipped off at the trace endpoints, and filed in the DGL.

Curved traces that run in the longitudinal direction are processed in a similar manner. The major difference is that the temporary major lines needed to intersect the trace at each input point are derived by cuts of the L-lines.

The primary outputs from HULSTRX are the following computer drawings of the design deliverables:

1. Midship section and typical sections,
2. Deck plans for all decks,
3. Expanded shell drawing, and
4. Deckhouse or superstructure.

These drawings will be made by specialized routines in some cases, or by employing the UPLOT program. In the course. of gathering the structural design data for the drawings,' the design geometry library will receive selected structural data and two new files will be created, a structural arrangement file, containing all structural traces to the level of detail corresponding to current contract design, and a structural scantlings file which will contain the scantlings of the steel shapes used in naval shipbuilding, as described in Reference 7.

The drawings will be made by referencing geometric data in the DGL and structural arrangement and scantling data in the other two files. Any further details will be obtained from computerized representations of the U.S. Navy standard structural details now under development, Reference 8.

Another important HULSTRX output will include a printed gross structural bill of material listing the structural elements and their quantities, in length or area units, by size of the members contained in the entire ship and/or for the individual surfaces.

It is hoped that the digital design data base, formed as a by-product of the contract design, will itself become a contract design deliverable, making it easier for those concerned with detail design to produce new or revised drawings. or to load detail design programs.

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NETWORK SCHEDULING OF SHIPYARD PRODUCTION, ENGINEERING AND MATERIAL PROCUREMENT

Marc Boucher
Director, Shipyard Planning Services
SPAR Associates Incorporated
Annapolis, Maryland

As Director of Shipyard Planning Services, Mr. Boucher is currently responsible for production planning and control services in shipyards, as well as system development and research. For the past 7 years, he has been involved in assisting various shipyards in the United States and Canada to improve their planning techniques and cost/schedule control systems. SPAR is currently engaged in providing production scheduling services to a number of yards in support of their planning staffs.

Prior to hi's involvement with SPAR, Mr. Boucher studied business administration and worked in management consulting.

PERT-PAC FEATURES

* Random network node numbering
* Multiple starting/ending, networks
* Sub-network,processing
* Multiple network processing
* Automatic network,loop detection
* Positive or negative activitylead time
* Automatic holiday and/or weekend schedule adjustment
* Automatic work week or shift adjustments
* Various activity sort list options
* Activity schedule bar charts
* Detailed node event schedule reports
* Summary milestone event schedule reports
* Critical activities analysis reports
* Activity cataloguing to work breakdown structure, production work centers, ship zone, and/or steel unit.

PERT-PAC

SPECIAL BENEFITS

* Direct access to WORK-PAC and performance information

* Simultaneous processing of preliminary planning work packages with actual, detailed production work packages

* Automatic re-scheduling of WORK-PAC options

* Automatic network updating; manual progress assessments not required

* Automated in-progress work adjustments

* Automated completed work adjustments

* Automated lead time adjustments

* Management visibility through schedule summary reports

    Milestone Report
    Critical Activity Report

* Schedule variance reporting

    - Automatic comparison of planned versus actual and current projected schedules
    - Total Project Slippage Report

* Automatic impact visibility of change orders and design changes

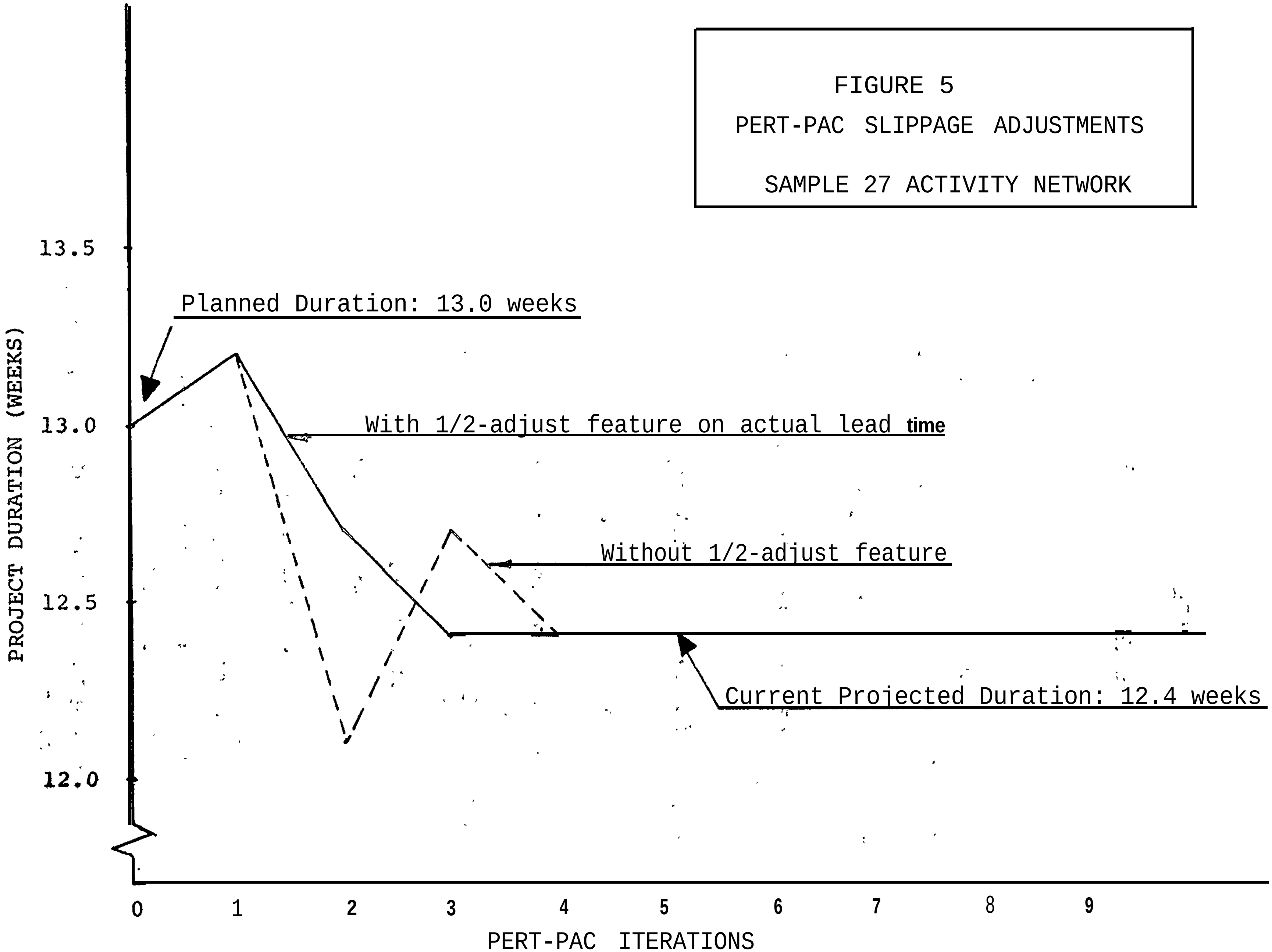
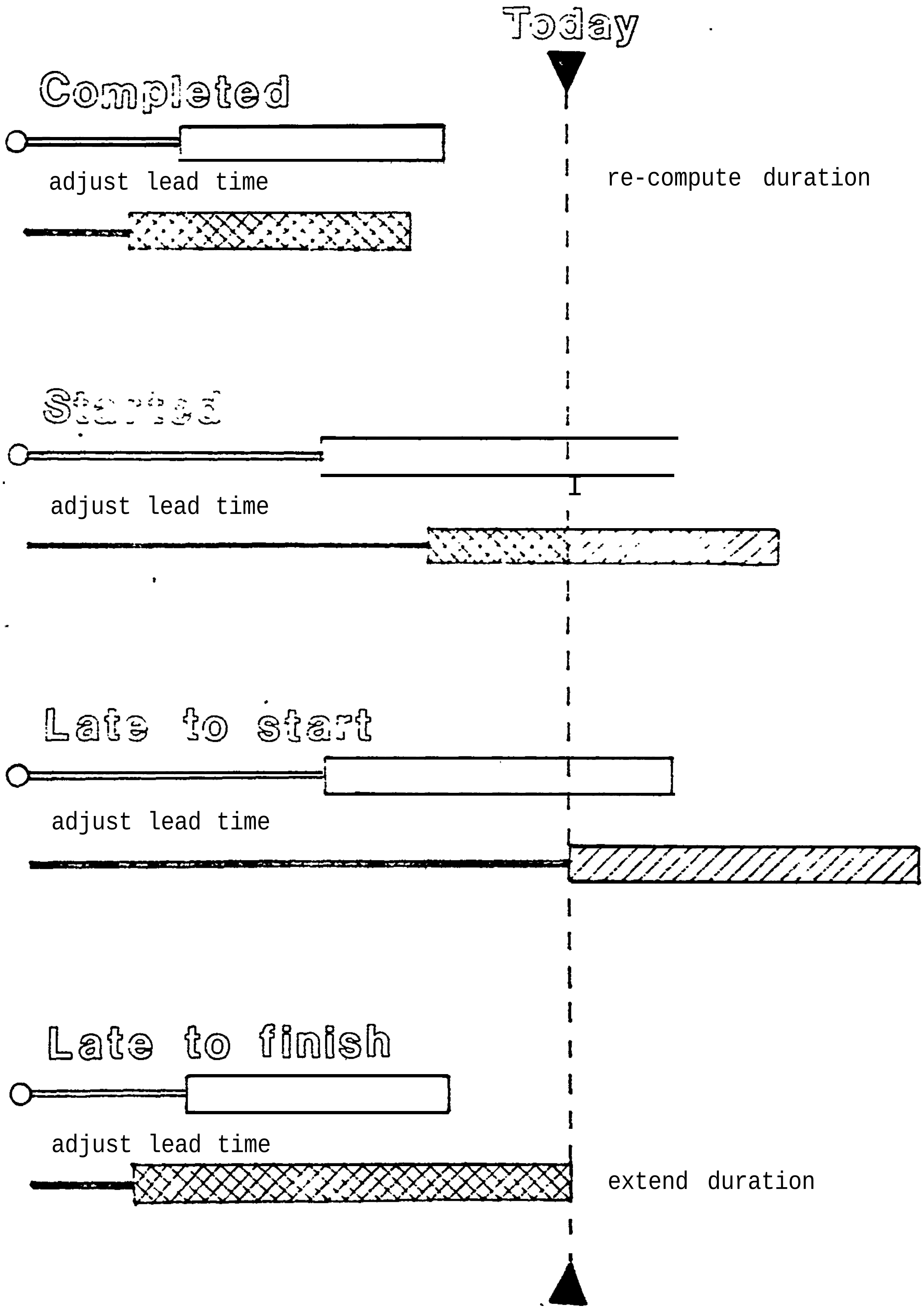


FIGURE 5
PERT-PAC SLIPPAGE ADJUSTMENTS
SAMPLE 27 ACTIVITY NETWORK

AUTOMATED ADJUSTMENTS



PERT-PAC CRITICAL ACTIVITY ANALYSIS   2/ 1/0   PAGE 1

HULL	W/C	PRG		PLANNED START	PLANNED FINISH	CURRENT START	CURRENT FINISH	WKS DELAY STAKT	WKS DELAY FINISH
1980.	0.	800.	REMOVE REFRACTIMATRL	1/ 5/0	1/15/0 C	1/ 3/0	1/14/0	-0.3	-0.1
1980.	0.	300.	REMOVE AIR REGISTERS	1/ 1/0	1/ 4/0 C	1/ 5/0	1/ 7/0	0.6	0.4
1980.	30.	400.	INITIAL HYDRO TEST	1/ 1/0	1/ 5/0 C	1/ 2/0	1/ 7/0	C.1	0.3
1980.	0.	1300.	REPAIR INNER CASING	1/15/0	3/ 7/0 S	1/11/0	3/ 3/0	-0.6	-0.6
1980.	0.	2300.	CHEM CLEAN TURBINE	3/ 7/0	3/11/0	3/ 3/0	3/ 7/0	-0.6	-0.6
1980.	0.	2400.	PRELIM HYDRO TEST	3/11/0	3/19/0	3/ 7/0	3/15/0	-0.6	-0.6
1980.	0.	2600.	INSTALL DRUM INTRNLS	3/19/0	3/28/0	3/15/0	3/24/0	-0.6	-0.6
1980.	0.	2700.	FINAL HYDRO TEST	3/28/0	4/ 1/0	3/24/0	3/27/0	-0.6	-0.7
1980.	0.	2800.	INSTL PLASTIC REFRAC	4/ 1/0	4/ 1/0	3/27/0	3/28/0	-0.7	-0.6
1980.	0.	1100.	EXPLORATORY BLOCK	1/15/0	1/30/0 S	1/15/0	2/ 1/0	0.0	0.3
1980.	0.	1700.	R-R SPR HT TUBES	1/30/0	3/ 1/0	2/ 2/0	3/ 2/0	0.4	0.1
1980.	0.	2100.	REPAIR OUTER CASING	3/ 7/0	4/ 1/0	3/ 3/0	3/27/0	-0-6	-0.7
1980.	0.	500.	REPAIR BILGE CASING	1/16/0	2/22/0 S	1/17/0	2/22/0	0.1	0.0
1980.	0.	200.	REMOVE BILGE CASING	1/ 1/0	1/16/0 C	1/ 3/0	1/17/0	0.3	0.1
1980.	0.	1200.	FINISH REPAIR CASING	2/22/0	3/25/0	2/22/0	3/26/0	0.0	0.1
1980.	0.	900.	REMOVE DRUM INTRNLS	1/ 5/0	1/ 8/0 C	1/ 3/0	1/ 9/0	-0.3	0.1
1980.	0.	2200.	RE-BRICK	3/ 7/0	3/17/0	3/ 3/0	3/13/0	-0.6	-0.6
1980.	0.	2500.	INSTALL AIR REGISTRS	3/17/0	3/25/0	3/13/0	3/21/0	-0.6	-0.6
1980.	0.	18[illegible].	R-R SUPPORT TUBES	1/30/0	3/ 1/0 S	1/27/0	2/25/0	-0.4	-0.6
1980.	0.	1000.	REPAIR SLIDING SEAT	1/23/0	2/22/0 S	1/20/0	2/18/0	0.4	-0.6
1980.	0.	600.	INSPECT SLIDING SEAT	1/16/0	1/23/0 S	1/17/0	2/ 1/0	0.1	1.3 *

CURRENT SCHEDULE SLIPPAGES HAVE CAUSED NETWORK TO SLIP -0.57 WORK WEEKS = -2.8[illegible] WORK DAYS

TOTAL DURATION 1/ 1/0 THRU 3/28/0   12.43 WORK WEEKS = 62.14 WORK DAYS)

FIGURE 8: PERT-PAC Critical Activity Analysis

MANPOWER PLANNING & CONTROL

From scheduled work packages, WORK-PAC develops

* Planned manpower
* Actual manpower expended to-date
* Projected manpower using production performance data

Special options include:

* Monthly averaging
* Trade breakdown detail
* Manpower Levelling
* Automatic generation of manhour "S" curve:
    : planned
    : actual
    : projected

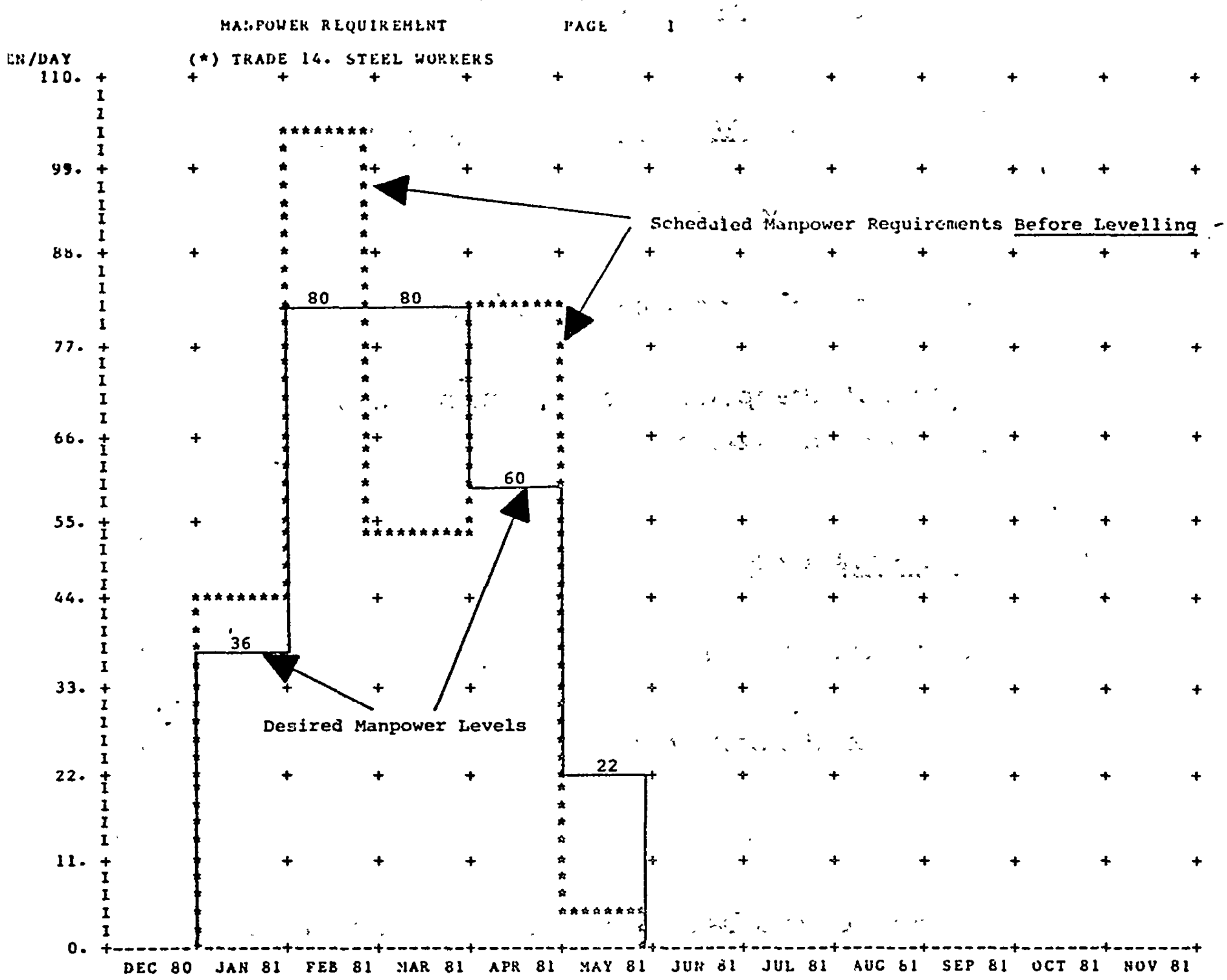


FIGURE 5c: Computer Generated (PERT-PAC) Manloading With Desired Manload Levels Superimposed

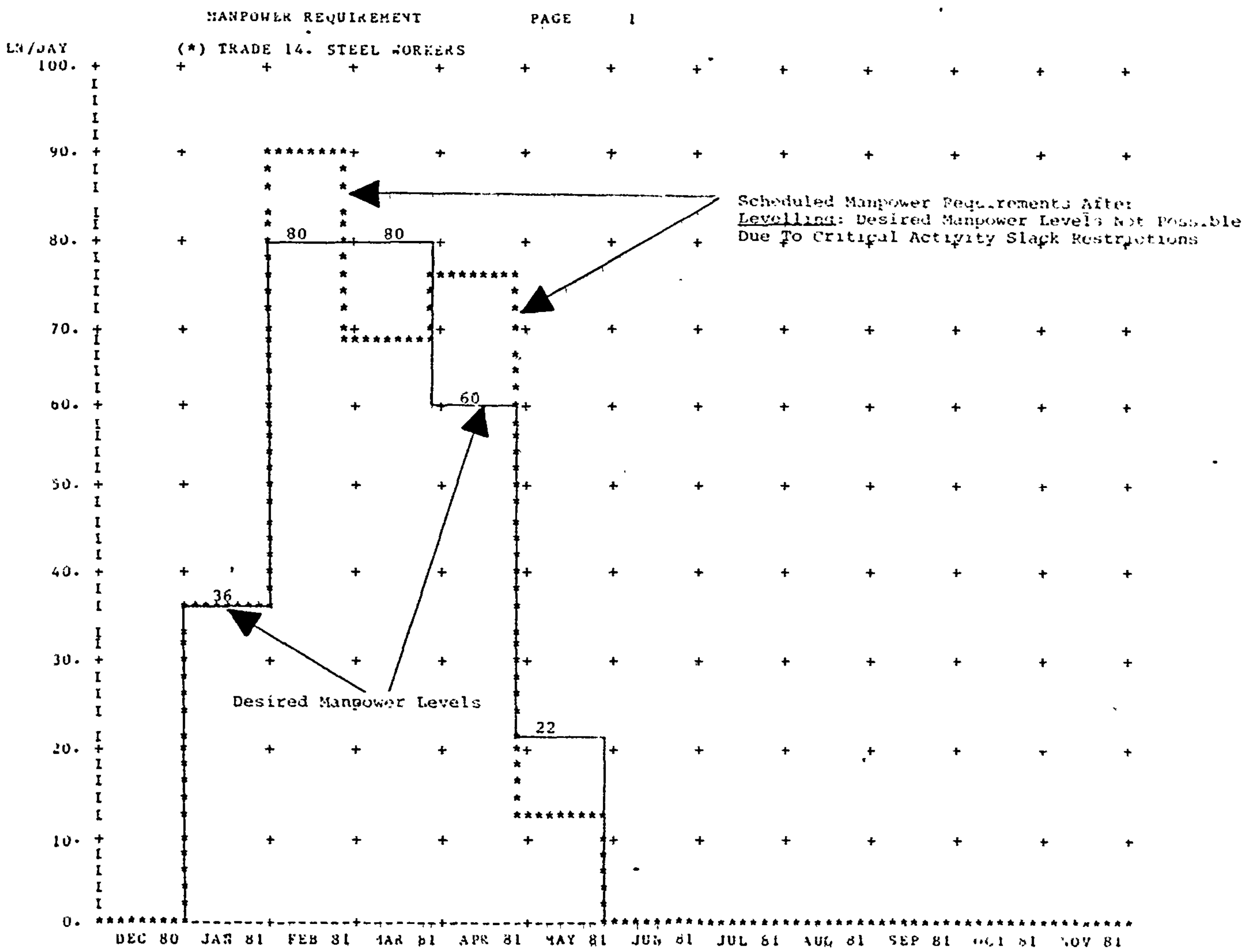


FIGURE 5d: Computer Generated (PERT-PAC) Levelling Of Manload Within Constraints Of Critical Delivery Schedules

MICRONETS

Pre-developed sub-networks:

* Can be used for any number of projects
* Can be used as often as needed within a given project
* Can be linked to other micronets

major Benefits:

* Increased Confidence in Network By Production and Management
* Reduced Network Development,Efforts
* Reduced Data Errors
* Reduced Opportunities To Neglect Important Activities

Disciplined & Orderly Network Logic:

* 'Improved Visibility Even With More Detail
* Easier Networks To Modify'

Special Feature

* Automated Activity Numbering
* Automated Node Numbering
* Automated Activity Budget Computations
* Automated Activity Duration Computations

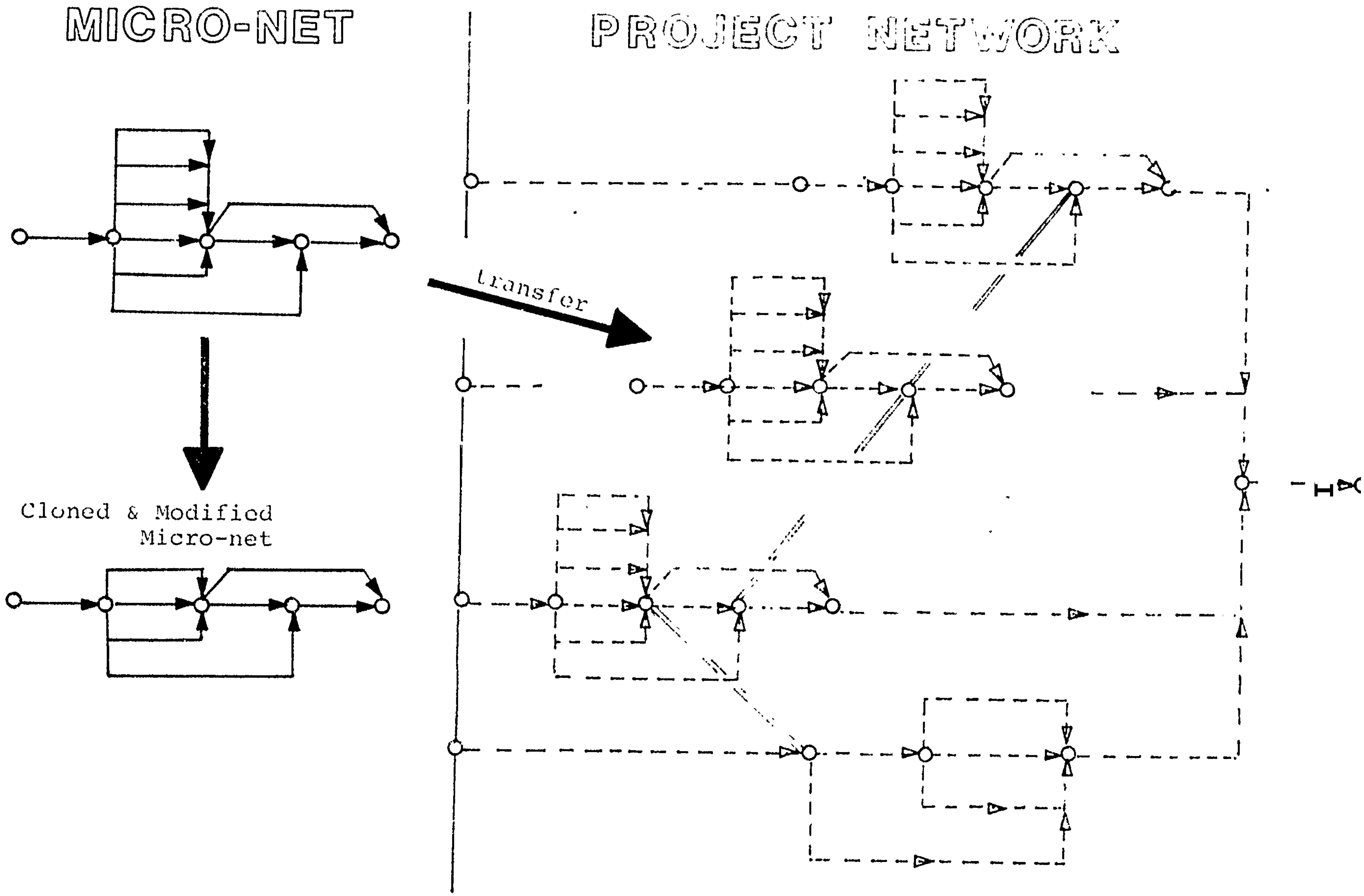
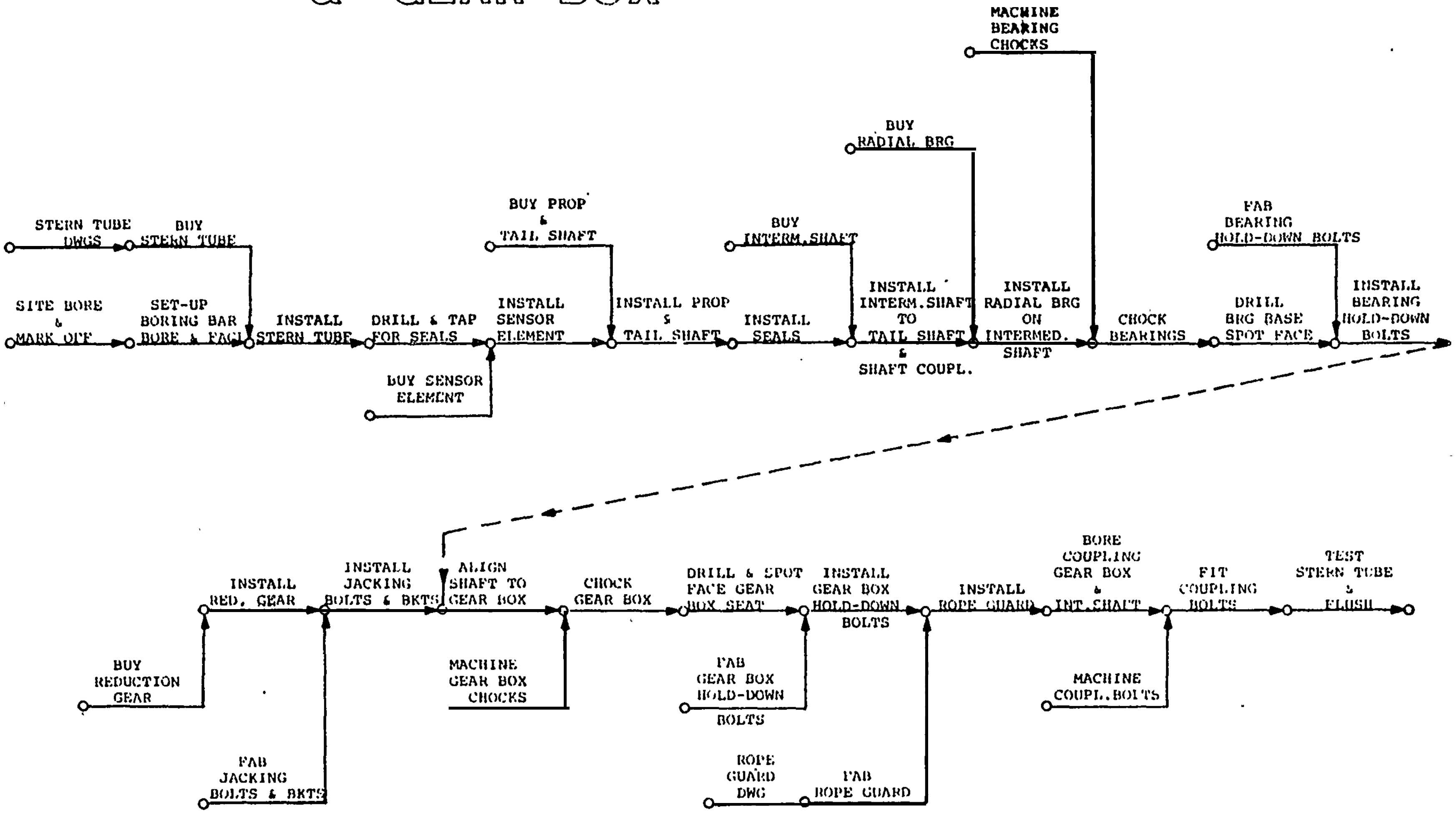


Figure 1: Transfer of micro-net from library to project network

PROPELLER, STERN TUBE, SHAFTING & GEAR BOX



SPAR ASSOCIATES INC

PLANNING AND SHIP OUTFITTING PRODUCTION CONTROL AT NEWPORT NEWS

Jerry Bollinger
Production Engineer
Newport News Shipbuilding & Dry Dock Company
Newport News, Virginia

Mr. Bollinger has been associated with Newport News Shipbuilding for the past 20 years. During this time he has held various management positions in construction and production planning. He currently is in charge of the material grouping, pipe shop planning, and computer generated pipe detail drawing preparations within the Production Engineering Department.

PLANNING AND SHIP OUTFITTING
PRODUCTION CONTROL AT NEWPORT NEWS

I. INTRODUCTION

This report provides a general overview of the techniques used in developing the Product Plan at Newport News, and covers in more detail the implementation and control of the plan, with emphasis on ship outfitting.

The intent is to inform interested parties about the Outfit,Planning. and Control Methods used at Newport: News., However, at this writing we are making extensive improvements to our material and production control systems. These improvements in time will alter some of the methods used in Outfit Planning and Control; and it is felt that these improvements may be of interest.

1.1 Material and Production Control Improvement(s)

The development and implementation of these improvements is complex, and involves almost all of the operating divisions. A committee has been established to coordinate and steer improvements. The committee is called "lMPCO Committee," and draws its name form improved material and production control.
the tasks either completed or in-process by the IMPCO Committee are:

- Develop Synchronized Schedules
- Standardization of Key Company Numbers
- Converting *to* and Cataloging Part Numbers
- Simplify and Improve Accuracy of Material Selection
- Improve Material Requirements Planning
- Improve Record Accuracy
- Simplify Shop/Ship Material Requisitioning
- Improve Shop Planning, Control, and Performance Measurement
- Develop a Product Structure for Outfitting Similar to Structural

This list is not inclusive of all the on-going improvements but only cites the major tasks.

2. DEVELOPING THE PRODUCT PLAN

Although our approach to developing a product plan is basic, and probably does not differ from techniques used by other shipbuilders, it is subject to change due to the aforementioned IMPCO Projects.

In developing a product plan there are three segments of the plan; 1) Structural, 2) Outfitting and 3) Manufacturing. As stated earlier, this report is slanted toward the outfitting segment of the plan. However, you cannot explain the outfitting plan without briefly covering the other two segments.

2.1 Planning and Scheduling

Planning and scheduling begin during the proposal evaluation before award of a contract. Availability of facilities, manpower, and long lead time materials are reviewed. Working from the proposed delivery date, established by the "Invitation to Bid," tentative award, keel, launch, and delivery dates are determined. The ship's size, its type and the company's past performance on similar ships are considered.

There are six basic documents or schedules that are paramount to the development of the product plan. Each document is an integral part of the plan and in most instances each is dependent on the other in terms of its development. These six documents are:

- Structural Erection Diagram (SED)
- Space Control Diagram (SCD)
- Ships Group Index and Schedule (SGIS)
- Ships Drawing Schedule (SDS)
- Material Ordering Schedule (MOS)
- Manufacturing Group Index and Schedule (MGIS)

Group Definition - A group is a definite quantity of material to be installed or manufactured as a unit or units. The quantity of material included in a group is intended to be such as to allow maximum efficiency in handling, storing and installation, with minimum interference to adjacent work.

The following is a brief explanation of these documents:

2.2 Structural Erection Diagram (SED) (See enclosure (1))

The Structural Erection Diagram is a drawing of the inboard profile of the ship with one or more cross sectional views and shows the sequence in which the ship will be erected.

Using the contract drawings and other available information, the ship is divided into sections usually along major structural boundaries, such as decks and water tight bulkheads._ These sections are further sub-divided into erection units with their size largely determined from'handiing considerations. Each erection unit is identified by a four digit number,'with the first two dipits indicating, the section number, and the last two indicating. the. planned sequence of unit erection within the section, 'for example

```
2008
  └─Indicates Unit Erection Sequence
└───Indicates Section Number
```

Also shown on the Structural Erection Diagram is a breakdown of the major events for each structural section,' such as':

Drawings and Groups Complete
. Material Available
. Molds Complete
. Fabrication Complete,
. Sub-Assembly Complete,
. Erect on shipway

2.3 Spaces Control Diagram' (SCD) (See enclosure (2))

The Space Control Diagram is developed for use in control of outfitting and aids in the development of the "Ships Group Index ,and Schedule" (see 2.4). This diagram divides the ship into space control divisons, each of which is identified by a.space control number. Normally the rule for defining space control divisions is one deck level extending the width of the ship bounded fore and aft by main'transverse.bulkheads.

Unlike the Structural Erection Diagram the space control divisions are not numbered in sequence of erection, but are structured for the control of outfitting groups assigned to a given space.

2.4 **Ships** Group Index and Schedule (SGIS) (See enclosure (3))

The SGIS,is the system that schedules the completion of outfitting groups both in the shops and on the ship. Using the "Erect on Shipway" date for structural sections; established in the Structural Erection Diagram,; as the scheduling date for start of outfitting, the Ships Group Index and Schedule is prepared. The nature of the SGIS is structure, system, and space oriented.' Each group' number is either combination of a structural erection units number and space cantrol number, or a

combination of an outfitting cost class number (system) and the space control number; for example

cost Class (System)	Group	Sub-Group	
2285	2000	100	Outfitting Group
2008	2000	100	Structural Erection Group

Identifies Space
Identifies Structural Unit Number
Outfitting System Number

Schedule dates are applied to these groups by establishing an installation start date (based upon the Structural Erection complete date on the Structural Erection Diagram) and working back through the following scheduled events(from latest to earliest);

. Installation Start
. Electrical Shop Complete
. Pipe Shop Complete
. Sheet Metal Shop Complete
. Machine Shops Complete
. Foundry Complete
. Material Available
. Groups and Drawing Issued
. Drawings Complete

Once developed the SGIS provides the scheduling framework for all other derivative schedules; Ships Drawing Schedule, Material Ordering Schedule, Manufacturing Group Index and Schedule, etc.

2.5 Ships Drawing Schedule (SDS) (See enclosure (4))

The Ships Drawing System (SDS) schedules the required drawings through the different design sections, and the applicable owner, for approval in time to meet the drawing need of the SGIS.

Design develops the SDS using the "Drawing Complete Date" established in the Ships Group Index and Schedule. Although some drawings may cover more than one group, the drawing is scheduled for completion to suit the earliest group shown in the SGIS. The SDS is inclusive of all the drawings required to construct the product, e.g. Structural, Piping, Electrical, Machinery, Ventilation, and Manufacturing drawings.

2.6 Material Ordering Schedules (M0S) (See enclosure (5))

The Material Ordering Schedule is the document that

schedules the in-yads date of the required purchased material to suit the Ships Group Index and Schedule.

The MOS is developed by Design in a manner similar to that used for the preparation of the Ships Drawing Schedule. Using- the SGIS,_"Contract Guidance Plans" and historical data, estimates are made of the gross material- requirements to be ordered from vendors.

These estimates are scheduled according to need and are further refined and the schedule updated as the drawings are developed.

2.7 Manufacturing Group Index and Schedules (MGIS) (See enclosure (6))

A manufacturing group is in effect a purchase order *to* ourselves requiring the manufacture of an item(s) to support the timely construction of the ship.

The Manufacturing Group 'Index and Schedule is developed by the applicable Design divisions and the construction projects. It schedules the manufacturing groups through the various shops to suit the material requirements of the Ships Group Index and Schedule.

3. IMPLEMENTING THE PLAN

The Ships Group Index and Schedule, Ships Drawing Schedule, Material Ordering Schedule and the Manufacturing Group Index and Schedule-provide the major building blocks for the Product Plan. These schedules are computerized and along with other computer systems (to be explained later) provide management with the tools to implement and control the Product Plan. The Plan is implemented as these' schedules and the applicable drawings are issued to Production Engineering and the construction trades.

3.1 Production Engineering (Outfitting)

Production Engineering is responsible for producing:

.Group Sheets (Material List)
Shop Work Packages'

'to suit the Ships Group Index and Schedule and. the Manufacturing : Group Index and Schedule by using the drawings- issued by Design: Upon review of the drawings and schedules it may be determined that a group has not been provided in the schedule(s) or a group in the schedule(s)'is not required. When this is determined appropriate action is taken to revise the schedules (MGIS or' SGIS).

3.2 Group Sheet Preparation

A Group Sheet is a listing of the required material keyed to a specific group (system and space) on the ship. The list authorizes work and provides quantities, description, sources, and routing of the material.

At present there are two methods of physically preparing group sheets; one is the conventional manual method and the other is a computer assisted method, referred to as AGS (Automated Grouping System). The AGS system closely audits all data and produces a more legible, standardized computer printed group sheet (See enclosure (7)).

It also interfaces with the "Inventory Management System" (IMS) to aid in the Material Requirements Planning (MRP). Also group sheets are structured to aid in the preparation of material requisitions.

3.3 Pipe Detail Grouping Section

The Pipe Detail Grouping section is responsible for specifying the boundaries for Pipe Shop Assemblies (called details), Which will be input to the CAPDAMS system (see section 3.4). This section also groups non-CAPDAMS material and prepares the preliminary piping arrangement drawing for use by the CAPDAMS section.

3.4 CAPDAMS Drawing Preparation Section (see enclosures (9) and (10))

CAPDAMS is the acronym for Computer Aided Piping Design and Manufacturing System which permits data entry and audit of pipe detail material and geometry data.

Using the prepared Preliminary Piping Arrangement Drawings, data is extracted and input to the CAPDAMS system. The system provides centerline check prints, individual Piping Detail Drawings and printed manufacturing instructions. In addition material requirements summed to the pipe detail level interface with the IMS system to aid MRP. The CAPDAMS output is issued to the Shop Work Package Planning Section.

3.5 Shop Work Package Planning Section

Upon receipt of group sheets and drawings, the Planning Section prepares and schedules work packages for the various shop(s) - Machine Shops, Steel Fabrication, Sheet Metal, Electrical and Pipe Shops, in accordance

with the SGIS or MGIS. A work package consists of a brief description of the item(s) to be made, the source for the required material, a schedule for completion, the target hours required to complete the work and the material requisitions.

The work package information is input to the "Production Scheduling Control System (PSC) (see section 4), and in the case of Pipe Shop Planning, input is made to the Pipe Package Ordering System which draws the material requirements from the CAPDAMS system by pipe detail and interfaces with the IMS system to check the availability and location of the material and, in addition; generates material requisitions and packing lists for the Material Support Division (see enclosure (8)).

4. CONTROLLING THE PRODUCT PLAN

The Ships Group Index and Schedule, being the ship schedule that all derivative schedules must support, provides adequate management controls at the group level. However, because of the number of items subordinate to the group requiring manufacturing, the system does not provide sufficient information required to most effectively manage a manufacturing shop.

A computerized shop scheduling and control system is used to provide feedback to the Ships Group Index and Schedule and provides the shops a tool to measure the day to day production performance. This system is known as the "Production Scheduling and Control System" (PSC).

4.1 Production Scheduling and Control System (PSC)

PSC provides

- On-Line Detailed Work Status
- Daily/Weekly Work Sequence Lists
- Target Hours for Foremen
- Work Performance
  - Completed versus Delinquent Work
  - Actual versus Target Labor
- Data for:
  - Make or Buy Decisions
  - Capacity Planning
- Schedule for Material Requisitioning

Requirements:

- Work Breakdown According to Predefined Work Centers
- Realistic Schedule Dates
- Realistic Target Hours
- Accurate Feedback

The PSC system used in our Shops provides the framework for a total yard work management system.

4.2 Yard Production Scheduling and Control

Our objective is to have a total mechanized yard production scheduling and control system, capable of providing many levels of management information. Our progress to date includes the linking of the individual shop PSC systems to the SGIS thereby creating the basis for such a system. As a result, we can make inquiries by a given contract and group number, and the system will access the applicable shop PSC data bases to determine detailed production status (see enclosures (11) through (14)).

CONCLUSION:

This report has provided a brief overview of the techniques and systems used at Newport News in developing, implementing, and controlling the Product Plan, and was prepared in the spirit that the information may be of interest to other concerns.

ACKNOWLEDGEMENT:

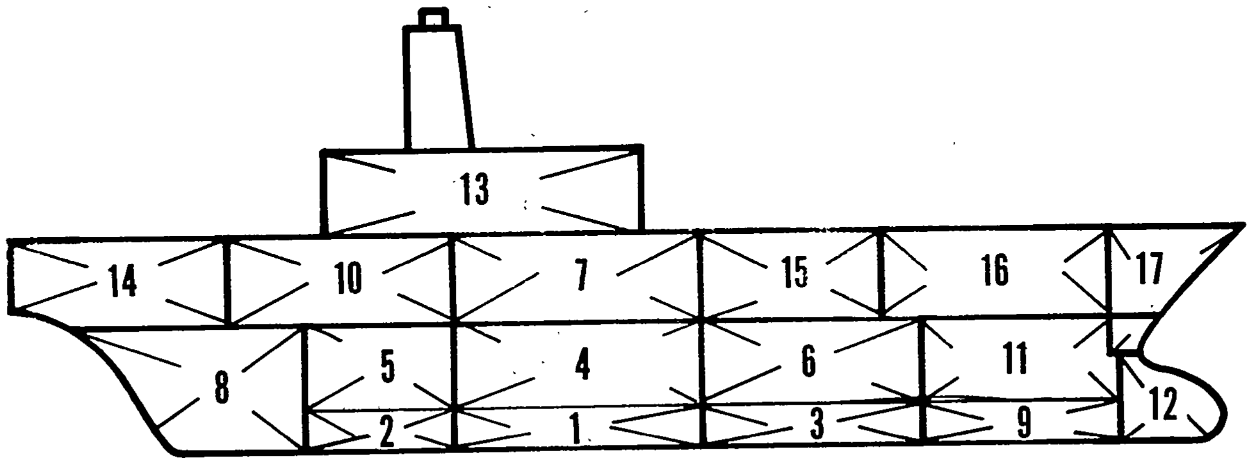
This author wishes to thank Mr. D. F. Carneal and Mr. E. C. Kizer of the Newport News Shipbuilding and Dry Dock Company for their assistance in the preparation of the data for this report.

REFERENCES:

(a) Report of Task Group for Improved Production Scheduling and Control," chaired by Mr. C. C. Coon, dated June 29, 1979.

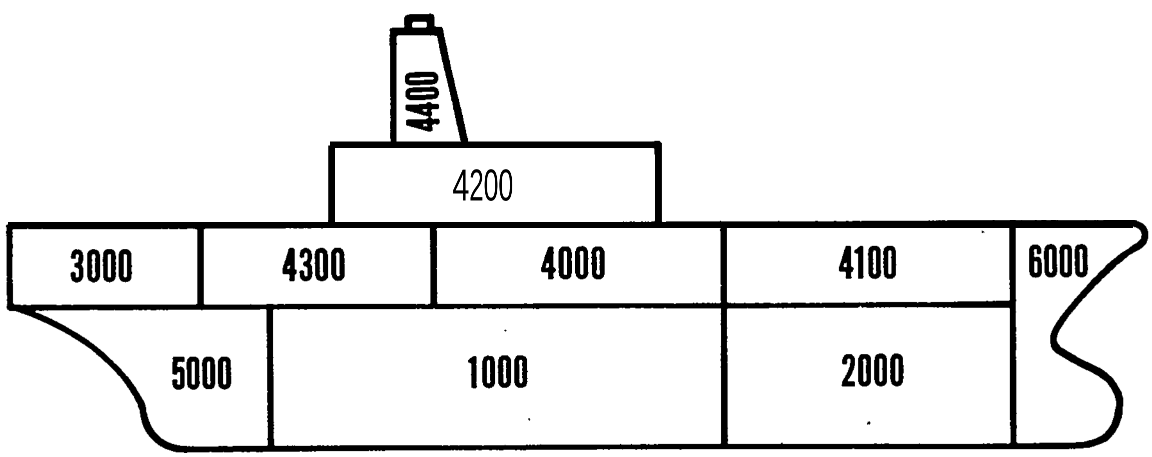
(b) "An Introduction to Grouping," Machinery Design Department, Newport News Shipbuilding and Dry Dock Company.

(c) "Production Control System," Newport News Shipbuilding and Dry Dock Company.



STRUCTURAL ERECTION DIAGRAM

Enclosure (1)



SPACE CONTROL DIAGRAM

Enclosure (2)

Enclosure (3)

SHIP'S GROUP INDEX & SCHEDULE

MATERIAL CONTROL - GROUP INDEX AND SCHEDULE - OUTFITTING JOB T006CJ-10 TOTAL

CLASS / GROUP NO. / SUBGRP. / SSGP.	DESCRIPTION	D/C	PREL DWG	DWG & LIST ISSUED	"A" MATL RECD	"C" MATL RECD	X 10 COMPL	FO COMPL	MSS COMPL	OA COMPL	PIPE SHOPS COMPL	EL SHOPS COMPL	EREC START	EREC COMPL
2300 42015511	ASSY 4200-11 SS H D S S PSARR 2300-889	P	159 06198	165 07318	165 07318						185 12188		186 12258	190 01229
2300 42015512	ASSY 4200-12 SS H D S S PSARR 2300-884	P	159 06198	165 07318	165 07318						185 12188		186 12258	194 02199
2300 42016511	HANGERS FOR ASSY 4200-11 2300-4201-5511	P	165 07318	169 08288	175 10098						185 12188			
2300 42036529	GM HANGERS FOR ASS 4200-29 2300-4203-5529 2300-2608	P	139 01308 03298	143 02278	149 04108					154 05158	159 06198			
2300 42036530	GM HANGERS FOR ASS 4200-30 2300-4203-5530	P	139 01308 11297	143 02278 11297	149 04108					154 05158	159 06198			
2300 42405700	BANK PIPING/H D FLUID 3RD PLATF PS FR 45-51 STBD 254798	P	149 04108 04188	155 05228	155 05228						169 08288		170 09048	186 12258
2300 42455700	BRANCH PIPING/HYD SYS PORT & STBD PS 2300-2458 1,2 3	P	149 04108 02038	153 05088 02038	159 06198						169 08288		170 09048	190 01229

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QUANTITY																														

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Enclosure (4)

SHIP'S DRAWING SCHEDULE

DRAWING SCHEDULE
N 58-1 (REV. J)

DEPARTMENT PLAN LIST — JOB T015CF — 0616D — JUN 26 1978 — 77

N. N. DRAWING NO. (03) / BUSHIP/M.A. DRAWING NO. (06) / REF. DRAWING NO. (07)	REV (45)	DWG TYPE (04) / AC PT APP (05)	SUPV. (08) / DEPT (09) / HULL SECT (10)	TITLE (11) → FOR SPECIAL JOB ORDERS / GROUP NUMBERS (01)	A INFO DWG (69)	B ETD & HTD TECH REVIEW IN (12)	C ETD & HTD TECH REVIEW OUT (13)	D APD TECH REVIEW IN (73)	E APD TECH REVIEW OUT (78)	F WEIGHT INFO IN (82)	G WEIGHT INFO OUT (86)	H TO DEPT HEAD (14)	I TO OWNER (18)	J K L M ABS LLOYDS USCG USPHS (22)	N TO GROUP (23)	O TO RT (29)	P YARD ISSUE (33)	CODED NO (44) / NOTES (40) / APPLICABLE (50)
23002444X2 518-5007480		12 6	DEK P	SS HYDR SYS FW PLN NORM MODE JOIN T MAP 2300 4000 500								168 08218				171 09118	173 09258	67890
23002446X1 516-5007481		2 6	DEK P	SS HYDR SYS PP ARR AMR STBD L/M & BM 2300 41005409								141 02138 02088			142 02208 02088	144 03068 02088	146 03208	3P 67890
23002446X2 516-5007481		2 6	DEK P	SHIP SERVICE HYDR SYS PP ARR-AMR STBD-PLAN EL & SECT 2300 41005409								141 02138 02088				144 03068 02088	146 03208	3P 67890
23002446X3		12	DEK	SS HYDR SYS PP ARR AMR STBD JOINT								141				144	146	3P
23002448X2 516-5007482		2 6	DEK P 1	SS HYDR SYS PP ARR 1&3 TT SRVS STBD HDR PLAN & ELEV 2300 42035529								139 01308 08317			08317	142 02208 08317	144 03068 09267	67890
23002448X3 516-5007482		12 6	DEK P	SS HYDR SYS PP ARR 13 TT SVCE STBD JT MAP 2300 42035529								139 01308 08307				142 02208 08307	144 03068 09267	67890

Enclosure (5)

MATERIAL ORDERING SCHEDULE

```
 DIV  M                HULL NO. 0616D    DIVISION           ORDERING SCHEDULE - P.O. SEQUENCE                         L-PAGE NO.  95
MC NO. 163
MC NO. DATE  07-17-78

                                        MFG PA  ENG     P.O. ORD ORD USE USE                     TEST CODED  QTY   NNCOST
PUR  ORDER  NO.  GROUP    . -     NUMBER LTW LTW ...   TYPE DPT SUP DPT SUP      NOTES          CODE NOTES  REQD  CHANGE        IDENT - NO.
PREL  FINAL DRFT  PREL   TECH   P--D  FINAL P.O        ..D  PLANS WORK  PLANS REQD                       ITEM DESCRIPTION                  N
SPECS SPECS TYPING PA    REVW   D--P   PA   PL.        APVL APPVD RELSD CCMP  YARD                    SERVICE APPLICATION DESCRIPTION   E
                                                                                                     SPECIFICATIONS       PSEUDO IDENT NO.W

 616D 2300P  1     2300  1000 700     060 010 012      1G  P   DEK  P  DEK C MATL ND          10301                                11036000
       070   071   0.1               093   003          .01   109   112   172   172  SERVO VALVES              531 PO 2300-68
      10046 10116 12.06             03147 03.07        ...7 07047 07257 0.103 03168 FOR HYD SYS
      05063 12105 12136             07316 07276        0..17                              N.N. DWG 215594

 616D 2.00V  2        M255626   1     020              .A  V   CGG  M  EH3                  00003                                13058000
      101                                                          103          123  GAGEBOARD ASSEMBLY
      05097                                                      05207        10107  FOR HYDRAULIC STORAGE TANK             EL GR 2C00-1000-
02017 0..27                                                      01040               2600

 616D 2.00K  2     2300  1403 300     044 019          1A  K   CBS  P  DEK A MATL RT ND       00301                                11032000
      033   062                       063   082                    002          126  ACCUMULATOR
      071.. 0....                    0.1C6 12276                  1227.        10217  FOR S/S SSD FLOOD CONT & EXT HYD SYS
      11016 0..93                    12146 03107                  03107

 616D 2...T  8     2300  4.00 100     024 008 006      1H  T   JDS  P  DEK A MATL          ALVA 10301                            11034000
      038   071   072   0.0           086   033   092   093   106   109   133  *133  HAND PUMPS           580 PO 2300-1
      0..06 10116 101.6 12136        01247 02077 03077 04167 0.137 070.7 12197 12197 FOR HYD SYS
      10036 11196                    12026 01127 04042 04042 11072 01127                  MIL-P-5315

 ...  2..0K  9     2200  11005336     060 007          1J  K   CBS  P  DEK A MATL ND       AXNA 00301                            11036000
      010   043                       044   051         037   053   051         *111  CHECK VALVES
      03036 03296                    04056 05246       07036 0.006 05246       07167  FOR HYD SYS
      02105 06203                    01126 03106       03287       03106                  NN DWG 230-1669

 616D 2300P 10     2300  1400 000     046 012 012      1H  P   DEK  P  DEK C MATL          ALVU 00301                            11039000
            056   057   039           081   003   007   093   101   104   150  *150  DEHYDRATION UNIT       WATER REMOVAL
            06233 07033 00276        12206 01037 01317 03147 05007 05307 04178 04178 FOR SS & STEER & STERN DIV SYS
            12015 12133 01037        01207 03217 04173 0.177 .5179 01030
            039   030   042           054   033                    056          126  VALVE BYPASS & UNLOADING
            12225 122.5 03226        06143 06298                  06283        10317  FOR HFP SS & STEER & STERN DIV SYS
            11105 11173 06256        06256 111.9 11196            11196                   N.N.DWG 215025

 616D 2000K 18     2300  1400 400     040 011          1A  K   CBS  P  DEK A-MATL RY       AXNA 0030D                            11173000
      092   095                       036   107                   107          *147  ACCUMULATOR  HYDRAULIC FLOATING PISTON TYPE
      03077 03287                    04047 05207                  05207        03276  FOR STERN DIVING EMERGENCY STORED ENERGY SYSTEM
      11245 03116                    08136 09135                  09163                   AS APPROVED
```

HONEYWELL PAGE P

MANUFACTURING GROUP INDEX & SCHEDULE

MATERIAL CONTROL - GROUP INDEX AND SCHEDULE - OUTFITTING JOB T006CJ-10 TOTAL

CLASS	GROUP	SUBGROUP	DESCRIPTION	D.C	PREL DWG	DWG & LIST ISSUED	"A" MATL RECD	"C" MATL RECD	X 10 COMPL	FO COMPL	MSS COMPL	OA COMPL	PIPE SHOPS COMPL	EL SHOPS COMPL	EREC START	EREC COMPL
2300	1429	1	MANF GAGE BOARDS 2300-2446-1		130 P112871226701028 0503705037	134	135						165 07318			
2300	2414	1	MANF FDN & RESILIENT MOUNTS 2300-1403-100		086 P012470221702287 0124712077	090	091		100 05027 14		118 0905709057	118				
2300	2426	1	HAND PUMP MANIFOLD STATION/VARIOUS S S ELCR 2300-1000-800		122 P100371031711077 1003701138	126	127		156 05298 X		154 051580529807038	156	161			

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QUANTITY																														

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Enclosure (7)

Figure F.2

006530

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PRODUCT   LINE*TS*DRAWING AND ITEM NO.          GROUP LIST----MACHINERY OUTFITTING GROUP                        DATE 09/22/77     *
STRUCTURE    MF*SC*SOURCE(MATERIAL IDENT NO.)   QUANTITIES LISTED FOR  1 SHIP(S)
                                                *QTY     UM*DESCRIPTION                                        * MATERIAL*ROUTING
                                                *TOT MTL  UM* MCLV  SSOR*SPECIFICATIONS OR NOTES               *          *CHG*
**********************************************************************************************************************************

 2        L81      6002-95#31                   *         4PC COVER-MBT VENT VALVE 4 A&B & 5 A&B               *ALUMINUM X/O-MS T*
            MF PO 6100-4059-H206#2              *  195.000SI             (IN PORT COVER)                       *         *       *
                  616
 2   A9   L82      6002-95#33                   *         4PC GASKET-13 OD X 10.125 ID X .125 THK              *BUNA-N    MS   T*
            MF PN 9779591                       *  196.000SI             FOR PC 31                             *         *       *

 2        L83      6002-95#34                   *         4PC SET SCREW #10-24 X .375 LG FL PT                 *NI-CU    ST-MS T*
               PN 9752805                                                                                      *         *       *

 2        L84      6002-95#40                   *        40PC SCREW-SCH CAP .500 X 1.125 LG SELF LOCKING       *NI-CU    ST-MS T*
               PN 9762929                                                                                      *         *       *

 2        L85      6002-95#41                   *        32PC SET SCREW .500 X .500 LG                         *TEFLON   SM-MS T*
            MF PN 9756424                       *   24.000IN                                                   *         *       *

 2        L86      6002-95#42                   *         4PC PIPE PLUG .500 RAISED SQ HD                      *CARBON STEEL   T*
               PN 9714170                                                                                      *         * ST-MS *

 2        L87      6002-98#51                   *         4PC SPRING RETAINER  MF 4.500 DIA BAR                *NI-AL-BRZ SM-MS T*
            MF PN 9737051                       *   24.000IN                                                   *         *       *

 2        L88      6002-98#52                   *         4PC SPRING                                           *BE-CU    ST-MS T*
               PN 5001212                                                                                      *         *       *

 2        L89      6002-98#53                   *         2PC GROOVED BUSHING  MF 4.500 DIA BAR                *NI-AL-BRZ SM-MS T*
            MF PN 9737051                       *   10.000IN                                                   *         *       *

 2        L90      6002-98#54                   *         2PC PLAIN BUSHING  MF 4.500 DIA BAR                  *NI-AL-BRZ SM-MS T*
            MF PN 9737051                       *   10.000IN                                                   *         *       *


DWG 4-A 4-C X10 MLD FO  QA  NSS FAB PF  EL  SA  GM  PH  E-S  GRPSTA TRADE ISSD TYGP*CONTRACT     *CHARGE    *GROUP   TRANS-ITL
  :   :   :   :   :   :   :   :   :   :   :   :   :   :   :   COM          061   MG *6160-7-8-9-0*6002      *6002-3000-100-0
...:...:...:...:...:...:...:...:...:...:...:...:...:...:...:                                            *        * SHEET 50
6002-3000-100-0          MBT 4 & 5 VENT VALVES & INTER COMM AFT             BY FIELDS J E     EXT 883460 *************************
                                                                                                 SOS
DD PH FD BL IH HS RM        NSS PM    PF PS GM PC OA OB EL RD WH MG EG PG MH AH X10 ML AMD RD HI SF 530 PTD LD SND RPR    LINE ITEMS
 :  :  :  :  :  :  :  :  :   :  :  :  :  :  :  :  :  :  :  :  :  :  :  :  :  :  :  :  :  :  :  :  :  :   :   :   :   :  1TU107
..:..:..:..:..:..:..:..:..:...:..:..:..:..:..:..:..:..:..:..:..:..:..:..:..:..:..:..:..:..:..:..:..:..:...:...:...:...:
```

Enclosure (8)

MATERIAL REQUEST

NN 300-103 (REV 1)

REQUEST NO	MATERIAL DESTINATION	RECIPIENT'S NAME	CONTROL LEVEL	IF ALL MATERIAL IS NOT AVAILABLE	1 X FILL WHAT IS AVAILABLE AND SHIP BAL. LATER	2 FILL WHAT IS AVAILABLE AND CANCEL BALANCE
99642PRO	100	NA	STD			

DATE ORDERED	REQUESTER'S SIGNATURE	DEPT	PHONE	REQUESTER'S SOC SEC NO	AUTHORIZED FOR (Job Order, I.R.)
	TILMAN	061	180-5216	231-70-0938	

DATE RECEIVED BY WAREHOUSE	CHARGE TO	ACCT HULL	JOB ORD	P L	SUB DIV	AUTHORIZED FOR (Group Only)	HULL	P L	COST CLASS	GROUP	SUB GROUP	S.S. GRP
		618		D	2355		618	D	2355	1 000	400	

Line	QUANTITY WANTED	U M	MATERIAL IDENTIFICATION NUMBER	DESCRIPTION	ISSUE U/M	LOC. 1	LOC. 2	LOC. 3	LOC. 4	LOC. 5	LOC. 6	ISS. QTY.	TRACE CODE	DRAWING	SHEET	REV.	PIECE NO	SHEET	LINE	ITEM
1	1.000	PC	9717086	CPLNG 1.250 X 1.000 BRZ REDUCIN FE	PC	R40959	31D6G11	31P124												
2	1.000	PC	9713458	FLANGE 1.000-150 LB BRZ SILVER BRA	PC	31E5C26														
3	4.000	FT	9821032	TUBING 1.660 NOM OD X 0.065 MIN CU	FT	23RAC188	23RAC293	23RACK79												
4	1.000	FT	9821028	TUBING 1.315 NOM OD X 0.065 MIN CU	FT	23RAC333	23RAC161	23CARD												

LINE	DEPT.	ESTAB. BY	DATE	C.P.	REL. BY	DATE	JOB NUMBER	PACKAGE	STAGING LOCATION
							618C02559	Sheet of	

053	COMMENT	EDD	CONTAINERS BOX BAG CAN	FILLED BY [ ] COMPLETE [ ] INCOMP	DATE FILLED MO. DAY YR	REQUEST NO
	99163207					99642PRO

NEWPORT NEWS SHIPBUILDING AND DRY DOCK COMPANY

ORIGINAL

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244

Enclosure (9)

PIPE DETAIL MANUFACTURING RECORD

BEND PIPE IN STEEL SHOP - MACH. 4
NOMINAL SIZE 5.00 THICKNESS 0.220

PTS	BEND NOS.	C.B.C.	DIST 1 TANG	D.B.T.	BEND RAD	CLOCKWISE ROTATION	BEND ANGLE	END PREP	TEMP	CUT	COORDINATES(TEMP NOT INCLUDED) X	Y	Z
1									3.00	6.85	42.170	6.000	0.
2	1	14.11	12.00	12.00	3.00	0.	16.0				37.920	6.250	0.
3	2	28.61	29.03	24.85	3.00	180.8	12.6				10.000	0.	0.
N		13.66	15.30	12.00				PN-1B	0.	7.53	3.875	0.	0.

DISTANCE FROM POINT 1 TO CENTER OF FIRST BEND 4.26
DISTANCE FROM CENTER OF LAST BEND TO POINT N 6.13

GROUP 2285- 4200-5502-

H	DEPT	STOP	NAME	DATE	CHARGE
U	6 6 6 6 6				
L	1 1 1 1 2				
L	6 7 8-9 0				

ORDER # 042182

	MIC	MATERIAL IDENTITY	QUANTITY	UNIT	DESCRIPTION	MATERIAL	PIECE	REV
BEND X X X X X	MC-I	PN9831259	0' 56	3/8"	5.563X.220 MIN.1863	CU-NI 70/30	+P171-1	A
X X X X X	MC-I	PN9713612	1	PC	5 FLANGE GROOVED	CU-NI 70/30	+FL1	A

NOTES
CLEANING-NN PROC-M83
WELD INDEX TABULATION DWG 2285-810
THIS DETAIL REQUIRES STAVE DAMPENING
THIS DETAIL IS PART OF ARRANGEMENT SUB-ASSEMBLY 4200-2
ALLOWANCE ON END OF PIPE AS INDICATED IS FOR TEMPL ABOARD SHIP
+ INDICATES NON-DEVIATIONAL MATERIAL, NO SUBSTITUTIONS ALLOWED
CONFIGURATION IS NON-DEVIATIONAL, NO VARIATIONS ALLOWED
WELDING - NN DWG C600-26, CL P1
BENDING AND FORMING - NN PROCEDURE M84

	PRE CLEAN	ACID CLEAN	DETG. CLEAN	BEND	MACH.	PS/CU BEND	DEGR -EASE	LAY OUT	FAB1	FAB2	WELD BRZ	NDT	GRADE CLEAN	TEST	REMV FLUX	GALV	DATE SHPD
DATE																	
SUPV																	
MECH																	
INSP																	

STOP-
RECEIVED-

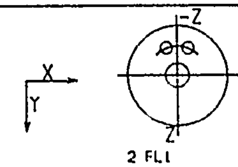
MC NO. 167

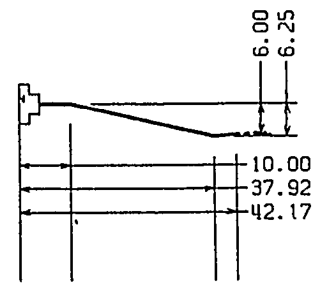
TAG P171-1
DETAIL A PAGE 1 OF 2
CAPDAMS ISSUED BY- HULL APPL. GROUP NO. ARRG DWG. 2285 - 808X1
05/04/79 MACH DES 616- 617- 618- 619- 620 2285- 4200-5502- DETAIL DWG. A2285 - 318 REV. B

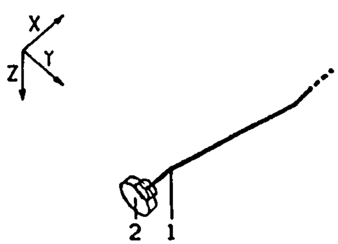
Enclosure (10)

CAPDAMS – COMPLOT

ID	PIECE NO	LOCATION	ORIENT	JT TY	JOINT NO.	NDT
1	P171-1	MAIN PIECE				
2	FL1	A ENON	2S-Z	PN-18	TD-20642	RT







DATE-
SIGNATURE-
LOCATION-

P171-1

DETAIL A	PAGE 2 OF 2
ARR. DWG. NO. 2285- 808Y1	
DET. DWG. NO. A2285 -318	R

CAPDAMS HULL APPL. GROUP NO.
05/04/79 616 617 618 619 620 2285- 4200-5502-

Enclosure (11)

PSC – GROUP INQUIRY

```
HULL P/L   CLASS GROUP SUBGRP SSGRP CD   ECD DC
617   D    2300  4102  5408     1    PS     P
DESIGN GRPNG A-MAT C-MAT X10 FO   MSS  DA  PIPE   EL   ES   EC
 132   136   140                           155         156   159
11138 12118 04239                         08069       08139 09039
02028 06128 01129                         X42A

CHEKPOINT? ALL
DO YOU WANT MATERIAL DUE STATUS? Y
x42 DIV
**********************************************************************

JOB NO=617C003401 DWG=                      WAIT MATERIAL RESP DEPT=X42
                  ASSEMBLY M41-9
                                              CODE  S

JOB NO=617C003402 DWG=A2300-732              COMPLETE     RESP DEPT=X42
                  ASSEMBLY S41-9
                  DET  A

JOB NO=617C003403 DWO=A2300-732              COMPLETE     RESP DEPT=X42
                  ASSEMBLY S41-9
                  DET  C

JOB NO=617C003404 DWC=A2300-732              COMPLETE     RESP DEPT=X42
                  ASSEMBLY 541-9
                  DET  D

JOB NO=617C003405 DWG=A2300-732              COMPLETE     RESP DEPT=X42
               ASSEMBLY S41-9
                  DET  F
```

Enclosure (12)

PSC – JOB STATUS BY WORK CENTER

```
JOB
AREA? PS
ARE YOU ON A HARD COPY TERMINAL? Y
WHICH WORK CENTER? 42C-MD40
START DATE? (MMDDYY) 031279
END DATE?   (MMDDYY) 062879
**********************************************************************
```

DOCUMENT	WORK ORDER	OP #	START	NORMAL	ACCUM	STATUS	PRIOR
618 D6200 7000 100	618C016013	005	052179	.0	.o	LATE	.0
618 D6200 7000 100	618C016012	005	052179	. 0	.0	LATE	.0
617 D2300 4203 5530	617C005639	005	062579	.0	.0	LATE	.0
617 D2300 4203 5530	617C005637	005	062579	.0	.0	LATE	.0
617 D2300 4203 5530	617C005636	005	062579	.0	.0	LATE	.0
617 D2300 4203 5530	617C005634	005	052579	.0	.0	LATE	.0
617 D2300 4203 5530	617C005632	005	062579	.0	.0	LATE	.0
617 D2300 4203 5530	617C005631	005	062579	.0	.0	LATE	.0
617 D2300 4203 5530	617C005629	005	062579	.0	.0	LATE	.0
618 D6200 7000 100	6l8C016031	005	052179	.0	.0	LATE	.0
618 D6200 7000 100	618C016030	005	052179	.0	.0	LATE	.0
618 D6200 7000 100	618C016029	005	052179	.0	.0	LATE	.0
618 D6200 7000 100	618_C016028	005	052179	.0	.0	LATE	.o

Enclosure (13)

PSC - WORK CENTER INFORMATION

```
*CTR
AREA? PS
ARE YOU ON A HARD COPY TERMINAL? Y
WHICH WORK CENTER? 43C-MO40

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

WORK CENTER=42C-MO40                 TEXT=MATL ORDERED

MACHINES= 0 MEN= 0 MOVE TIME= 0 OTIME= 0 DAY LEN= 8 OVRHD RATE= 0

MACHINE RATE=    .OO LOAD CODE=1 LOAD PERCENT=085 BASIC CAPACITY= 8

WORK CTR SETUP LOSS= 0 WORK CTR LOSS FACTOR= .00 SU/PROC RATIO= 0
```

Enclosure (14)

PSC - ORDER STATUS DATA

```
*STA
AREA? PS
ARE YOU ON A HARD COPY TERMINAL? Y
*TYPE             G
CONTRACT OR JO    617
PRODUCT LETTER D
COST CLASS        2300
GROUP             4102
SUBGROUP          5408
SUBSUB
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
ORDER=617C003401 DESC- L000002 M41-9           RESP-42 DEL, WORKING
ORDER=617C003402 DESC- L000000 S41-9           RESP-42 COMPLETED
ORDER=617C003403 DESC- L000000 S41-9           RESP-42 COMPLETED
ORDER-617C003404 DESC- L000000 S41-9           RESP-42 COMPLETED
ORDER=617C003405 DESC- L000000 S41-9           RESP-42 COMPLETED
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
WHICH WORK ORDER? 617C003401

**********************************************************************************
```

OP0	WORK CENTER	START DATE	NORMAL HOURS	ACCUM HOURS	LOCATION	COMP DATE	CONTROL TICKET #
005	42C-MD40	080679	.0	0.0	*	*070279	150-31254-14213
010	42C-MR40	083079	.0	0.0	* 070279	*	150-31255-14210
022	42C-4022	090379	.0	0.0	*	*	150-31256-14217
032	42C-4032	091079	.0	0.0	*	*	150-31257-14214
037	42C-4037	091779	.0	0.0	*	*	150-31258-14211
070	42C-4070	100179	.0	0.0	*	*	150-31259-14218
080	42C-4080	101579	.o	0.0	*	*	150-31260-14214
085	42C-4085	102279	.0	0.0	*	*	150-31261-14211
999	42C-CL40	102279	.0	0.0	*	*	617-03401-14218

AN INTEGRATED INTERACTIVE PLATE NESTING AND MANUFACTURING PLANNING SYSTEM

John M. Wallent
Chief of Automated Processes
General Dynamics Corporation
Quonset Point Facility
North Kingston, Rhode Island

Mr. Wallent as Chief of Automated Processes is currently responsible for numerical control applications and support for the Quonset Point facility, including lofting and central trade planning.

For the past 25 years, Mr. Wallent has been involved in the production areas of shipbuilding and in computer applications. He has held the position of Manager at a software vendor company, and has assisted many yards in the United States and Canada over the years.

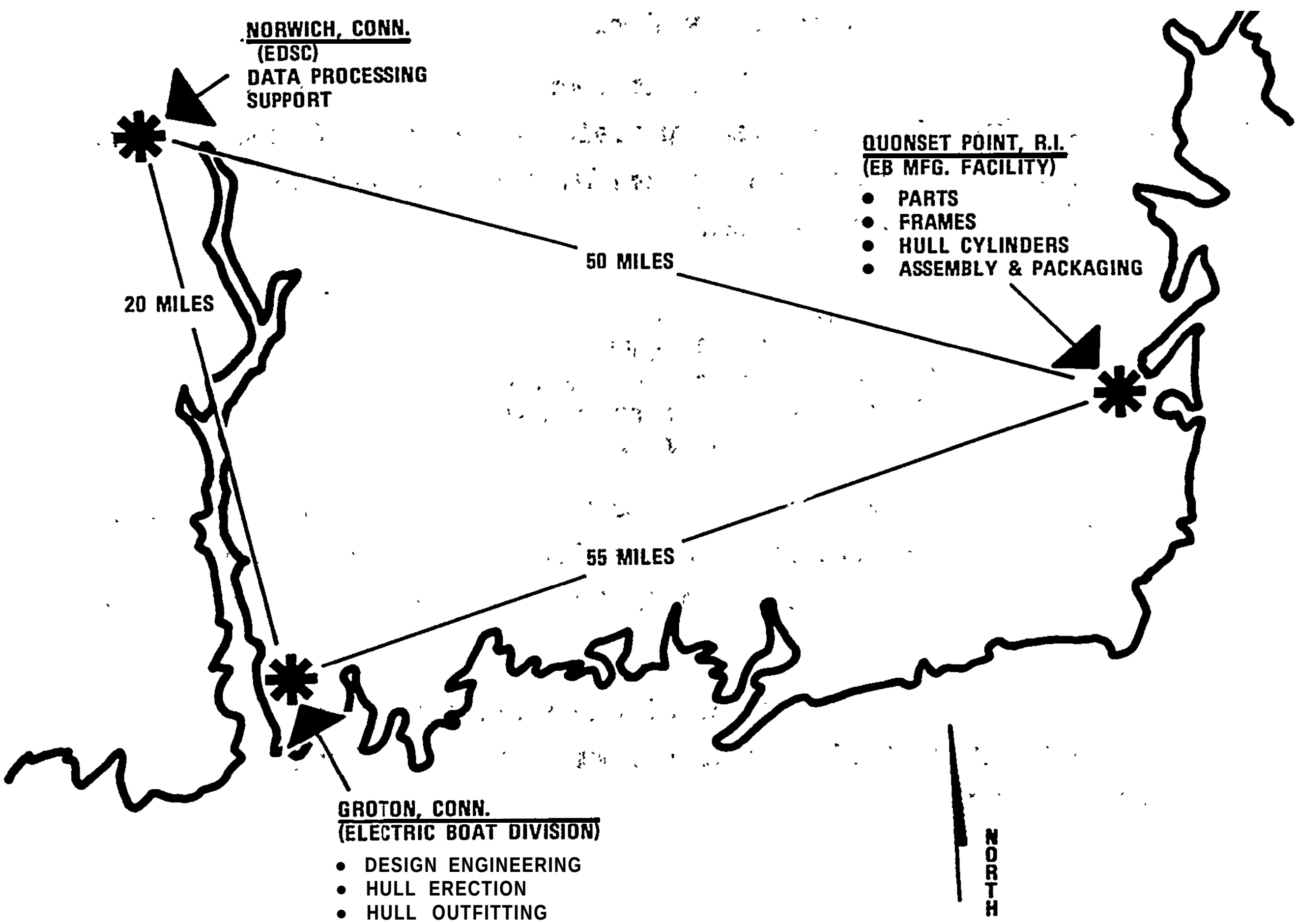
Paul M. Cofoni
Chief, CAD/CAM
General Dynamics Corporation
Eastern Data Systems Center
Groton, Connecticut

Mr. Cofoni is responsible for data processing support of computer aided design and manufacturing at the Electric Boat Division of General Dynamics. He is a graduate of the University of Rhode Island with a degree in mathematics.

Mr. Cofoni previously held the position of systems analyst, responsible for data processing support of structural computer aided design and manufacturing at General Dynamics.

AN INTEGRATED INTERACTIVE PLATE NESTING AND MANUFACTURING PLANNING SYSTEM

FOR THOSE OF YOU WHO ARE NOT FAMILIAR WITH THE FUNCTIONAL RELATIONSHIPS BETWEEN ELECTRIC BOAT GROTON AND THE QUONSET POINT MANUFACTURING FACILITY, THEY ARE SEPARATED BY APPROXIMATELY 55 MILES. THE QUONSET FACILITY PERFORMS PART, FRAME AND HULL CYLINDER FABRICATION, AND ASSEMBLY AND PACKAGING OPERATIONS. SHEET METAL, ELECTRICAL, PIPE AND MACHINE SHOPS ARE ALSO LOCATED AT QUONSET. MAJOR ITEMS ARE BARGED TO GROTON WHERE DESIGN ENGINEERING FUNCTIONS, HULL ERECTION OUTFITTING, AND OVERHAUL ARE PERFORMED.



TYPE OF WORK

LARGE CONSTRUCTION UNITS

- LONG LEAD AND STAGING TIME
- LOW RESPONSE TO SCHEDULE CHANGES

SMALL CONSTRUCTION UNITS

- PARTIAL PLATE NESTING
- LOW STEEL UTILIZATION
- EXCESSIVE MATERIAL HANDLING
- LOW MACHINE UTILIZATION

ABOUT TWO YEARS AGO OUR FACILITY UNDERWENT SOME MAJOR CHANGES IN MANAGEMENT AND IN PHILOSOPHY. A HARD LOOK WAS TAKEN AT OUR METHODS OF OPERATION AND WHAT STEPS NEEDED TO BE TAKEN TO MAKE US MORE PROFITABLE. THE SIZE OF WORK UNITS HAVE TREMENDOUS VARIATIONS IN TIME SPANS, FROM A FEW DAYS TO TWO YEARS, AND SPECIAL PROBLEMS WERE IDENTIFIED WITH BOTH LARGE AND SMALL UNITS.

OUR PLANNING AND SCHEDULING SYSTEMS WERE DONE BY HAND AND THE WORK WAS REPEATED FOR EACH SUCCESSIVE HULL. ALL WORK WAS SCHEDULED TOE TO HEEL AND EACH UNIT TREATED AS AN ENTITY OF ITSELF. THIS METHOD CAUSED US TO CUT AND FORM THE ENTIRE UNIT BEFORE THE START OF ASSEMBLY. FOR LARGE UNITS LONG LEAD TIMES WERE REQUIRED WHICH CAUSED SLOW RESPONSE TO SCHEDULING, AND IN ADDITION LARGE PARTS INVENTORIES WERE BEING MAINTAINED. MANY PROBLEMS WERE ENCOUNTERED WITH CHANGES DURING THE STORAGE PERIOD.

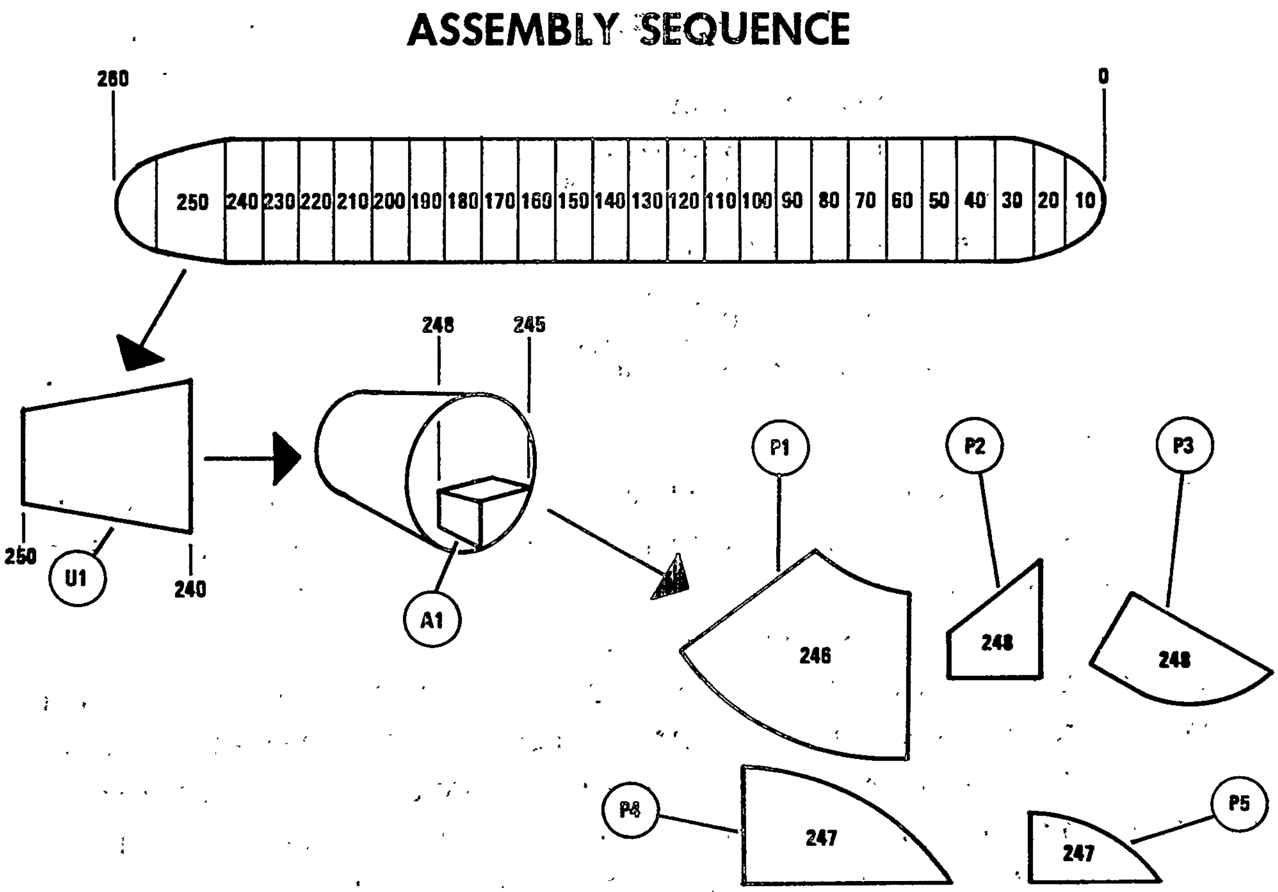
FOR SMALL UNITS PLATE UTILIZATION BECAME A PROBLEM. PARTIAL PLATE NESTING WAS BEING DONE TO MAINTAIN UNIT INTEGRITY. THIS CAUSED EXCESSIVE MATERIAL HANDLING AND LOW CUTTING MACHINE UTILIZATION.

REQUIREMENTS

- REDUCE STAGING INVENTORY
- PROVIDE PLANNING AND SCHEDULING PAPER AUTOMATICALLY
- IMPROVE PLATE AND EQUIPMENT UTILIZATION

IT WAS DECIDED TO PUT A SYSTEM TOGETHER TO MEET THREE SPECIFIC REQUIREMENTS.

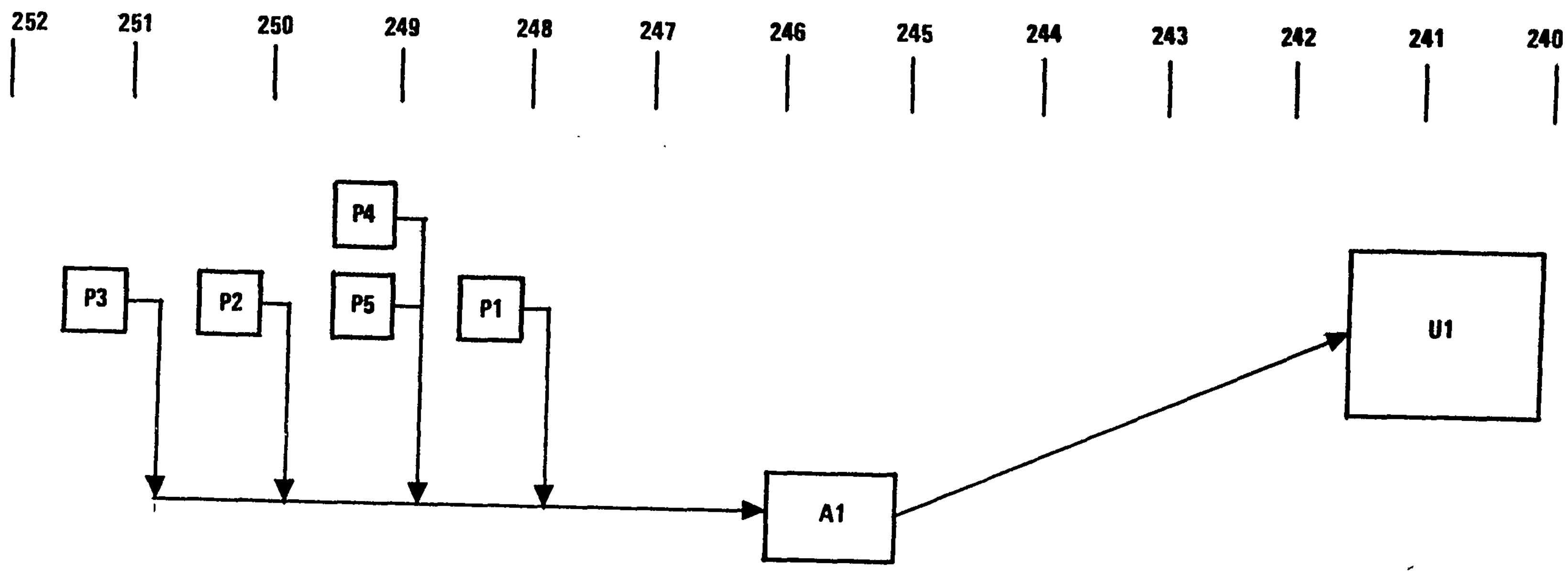
1. REDUCE THE STAGING INVENTORY TO SOME SPECIFIED WORKING TIME SPAN.
2. PROVIDE A METHOD TO PLAN AND PRODUCE SCHEDULING AND TRADE WORK INSTRUCTIONS AUTOMATICALLY.
3. IMPROVE THE PLATE AND EQUIPMENT UTILIZATION TO A MORE ACCEPTABLE LEVEL.



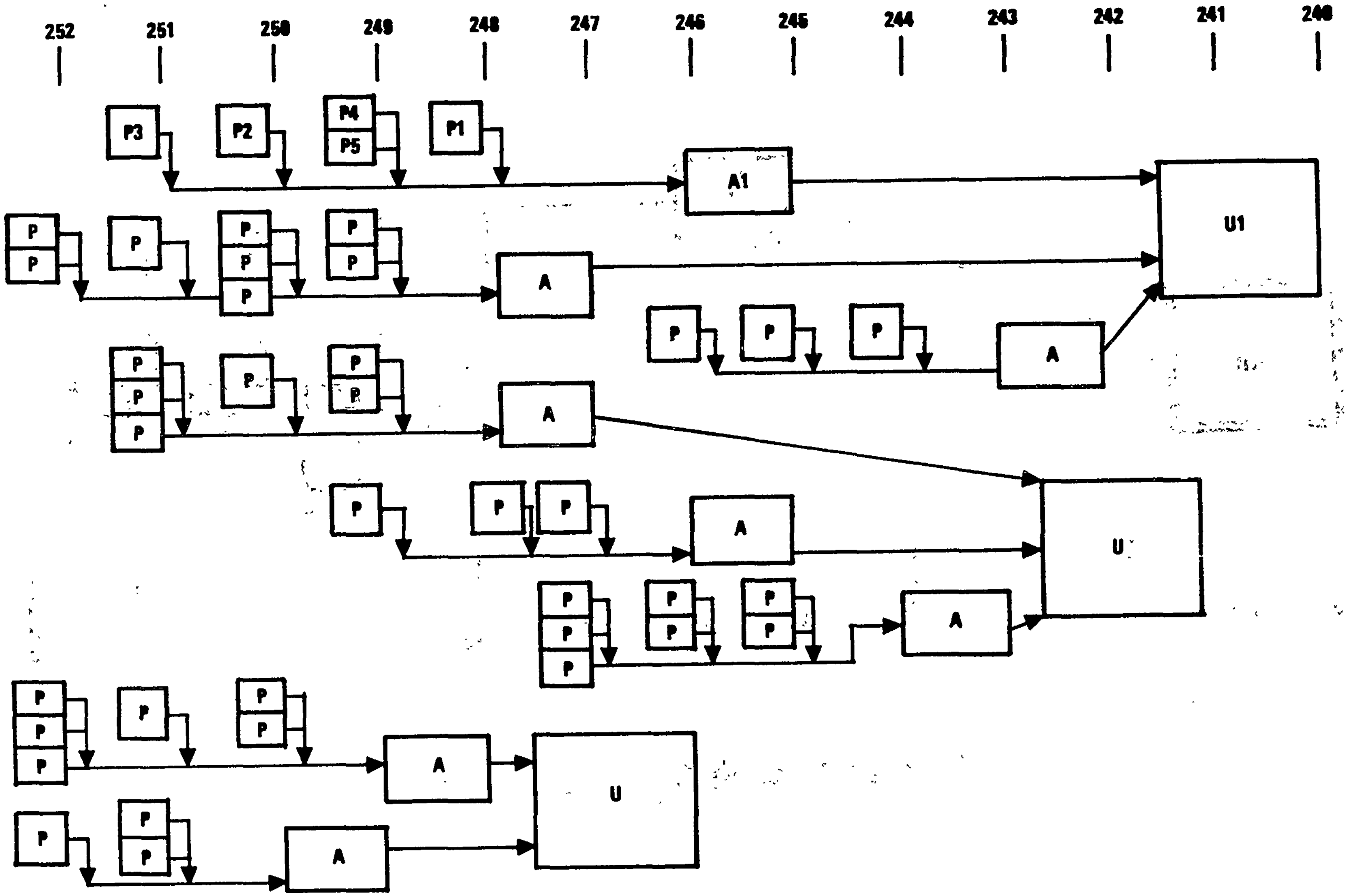
THE FIRST STEP IN ACCOMPLISHING THESE GOALS HAS TO ESTABLISH A METHOD OF WORKING WITH THE MATERIAL REQUIRED DURING A TIME FRAME RATHER THAN BY TOTAL UNITS. TO DO THIS, EACH SHIP (SUBMARINE IN OUR CASE) WAS DIVIDED INTO UNITS REPRESENTING THE NUMBER OF WEEKS OF CONSTRUCTION. ZERO WAS DESIGNATED AS REPRESENTING DELIVERY OF THE HULL. THE DELIVERY DATE OF EACH UNIT FOR ASSEMBLY TO THE MAIN HULL WAS THEN FIXED AT ITS CORRESPONDING WEEK. SUB-UNITS AND PARTS WERE BROKEN OUT AND ALSO ASSIGNED WEEK NUMBERS.

THIS CHART IS A GRAPHIC REPRESENTATION OF HOW THIS IS ACCOMPLISHED. THE COMPLETION DATE (TIED TO THE SEQUENCE) IS ESTABLISHED FIRST AND SPAN TIMES FOR EACH PRIOR OPERATION BACKED OUT UNTIL THE CHART IS COMPLETED.

MANUFACTURING METHOD



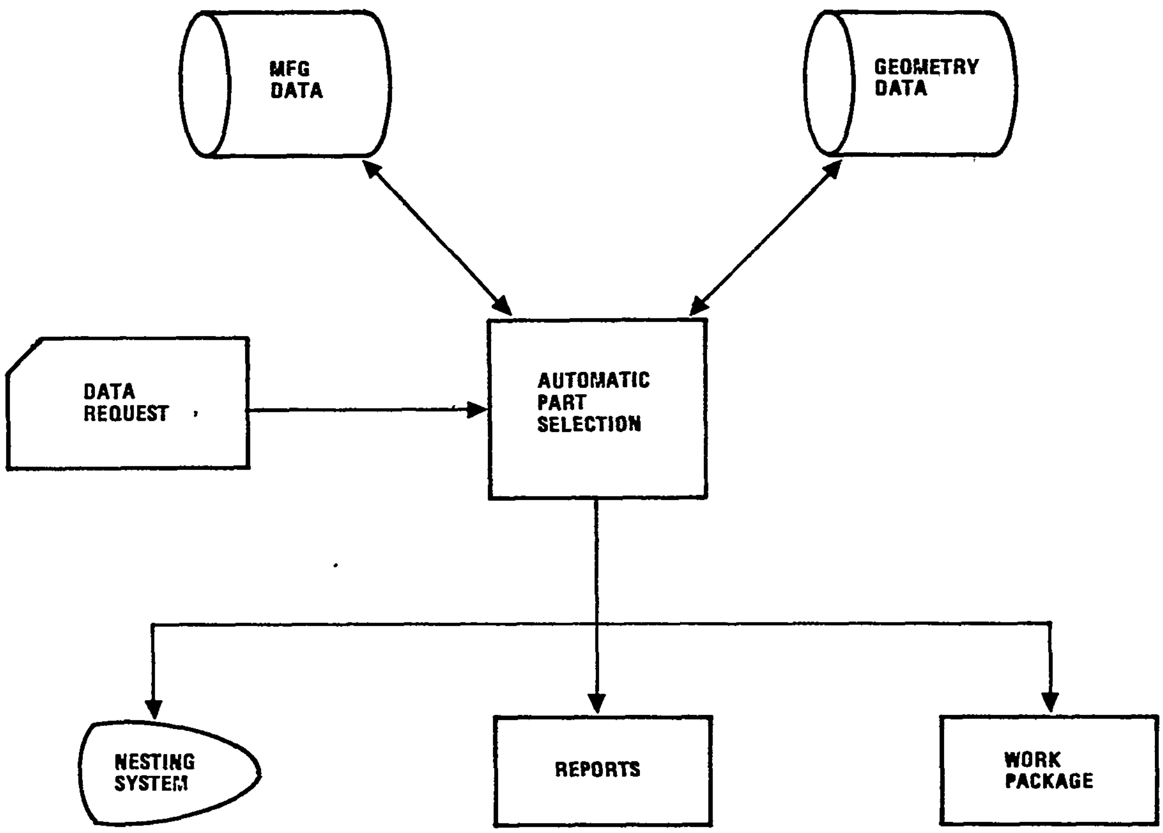
MANUFACTURING MODEL



THIS SLIDE SHOWS HOW SEVERAL UNITS LOOK WHEN OVERLAID. A "WINDOW" OF THE DESIRED TIME FRAME IS TAKEN AND THE CANIDATES FOR NESTING CAN THEN BE EASILY IDENTIFIED.

INFORMATION ABOUT EACH UNIT IS LOADED INTO A COMPUTER FILE DOWN TO THE PART LEVEL.

OVERVIEW OF STRUCTURAL CAM SYSTEM



THE COMPUTERIZED SYSTEM IS COMPRISED OF THREE MAJOR MODULES.

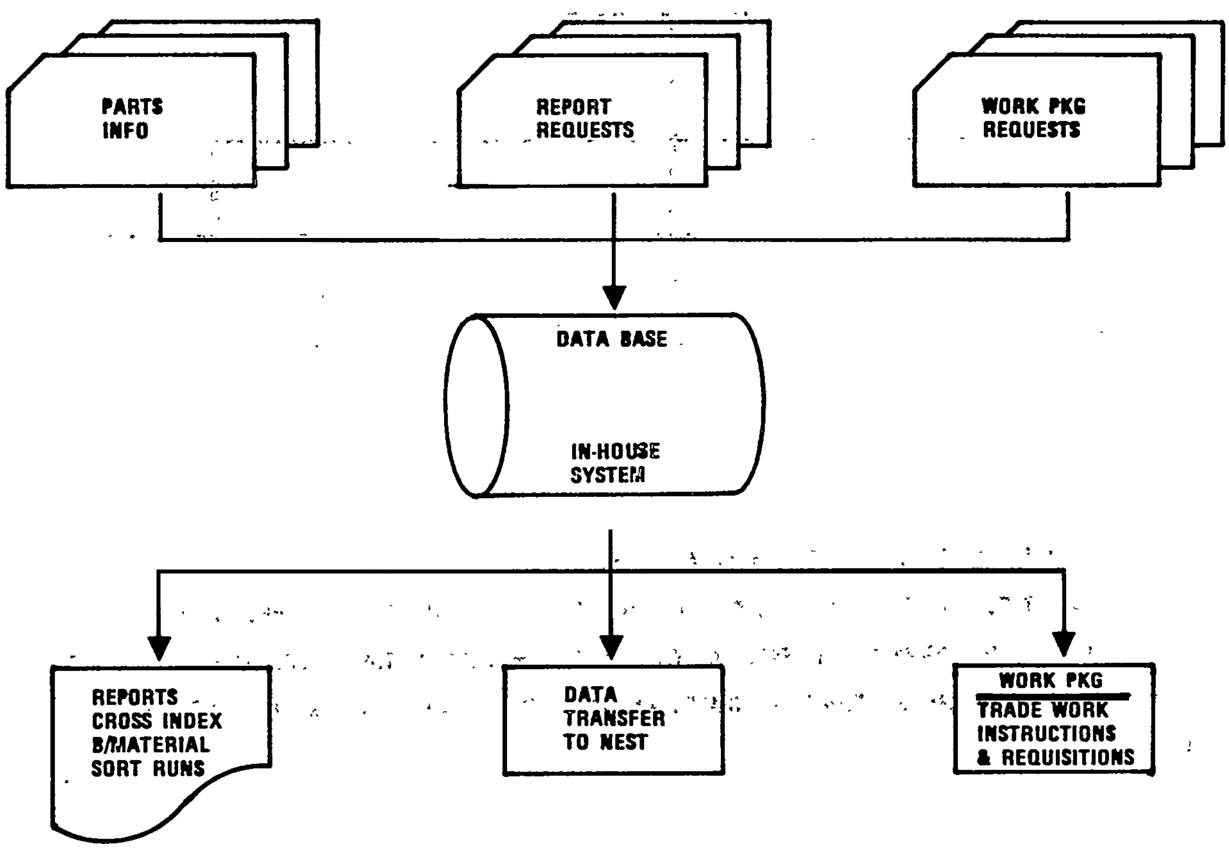
THE MANUFACTURING DATA FILE, THE GEOMETRY FILE, AND THE INTERACTIVE NESTING SYSTEM. THESE THREE ARE TIED TOGETHER BY A SELECTION PROGRAM WHICH REACTS BY THE SEQUENCE NUMBERS OF THE REQUESTED HULLS. RULES ARE APPLIED IDENTIFYING WHICH ARE LEGITIMATE CANIDATES AND AN AUTOMATIC CHECK OFF IS MADE TO TRACK COMPLETED OPERATIONS.

MANUFACTURING PLANNING

- FABRICATION AND ASSEMBLY SEQUENCES
- SPAN TIMES AND LEAD TIMES
- FEED TO FEED RELATIONSHIPS
- COMPLETION PERIOD
- MATERIAL REQUIREMENTS

THE MANUFACTURING FILE HAS A 300 CHARACTER RECORD FOR EACH PART. THIS INFORMATION STARTS WITH IDENTIFICATION OF THE RAW STOCK AND ENDS WITH THE COMPLETED UNIT. THE SEQUENCE NUMBERS FOR EACH STEP ARE ASSIGNED, THE GEOMETRY IDN (AUTOKON NO.), ALL SPAN TIMES FOR CONSTRUCTION, LEAD TIMES FOR FLOOR PLANNING, FEED TO FEED RELATIONSHIPS, CHARGE NUMBERS, AND COMPLETION DATES ARE LOADED IN THIS FILE.

MANUFACTURING FILE

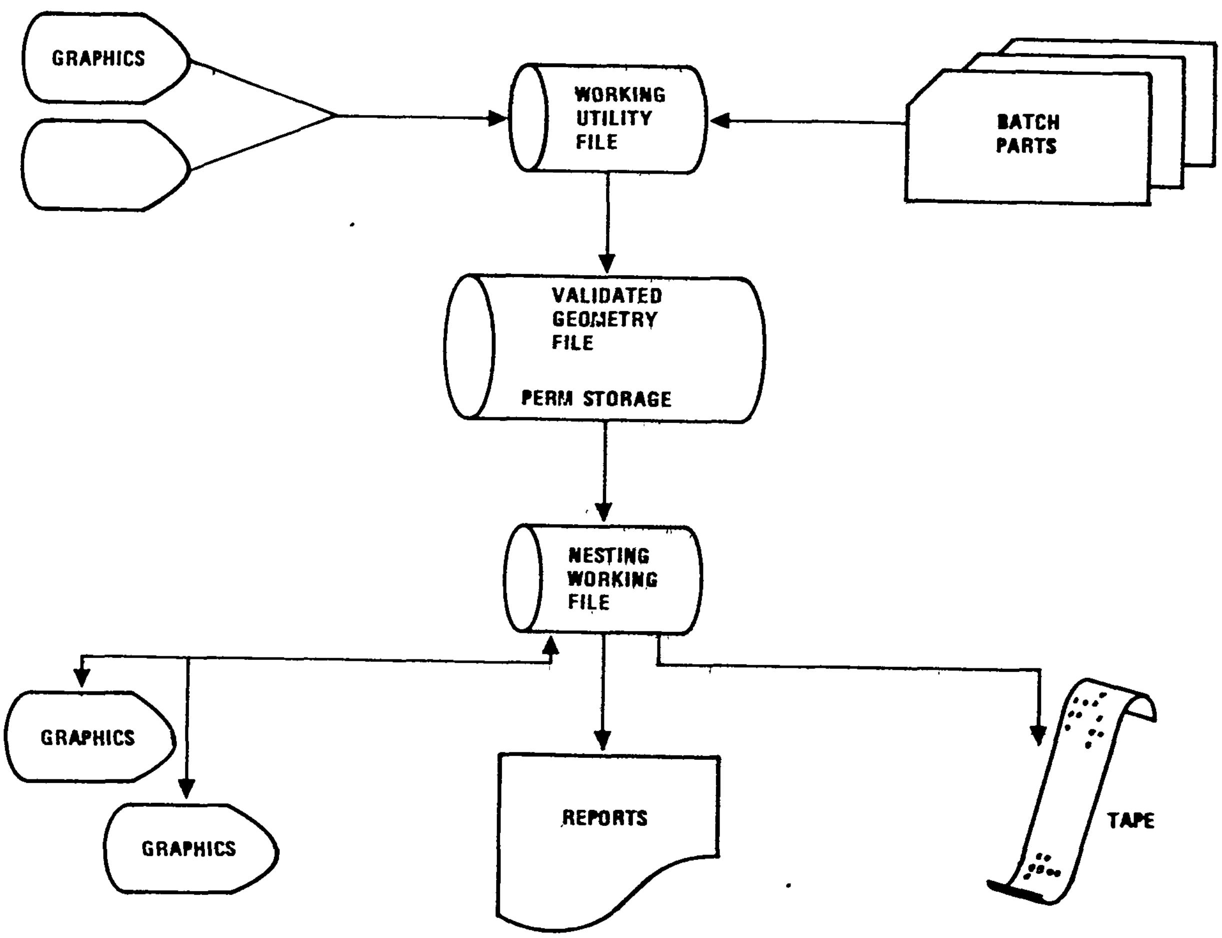


AUTOMATED OUTPUTS

- MATERIAL REQUISITIONS
- TRADE WORK INSTRUCTIONS
- BILL OF MATERIAL/STAGING AND ASSY INVENTORY LISTS
- PLANNING REPORTS

AUTOMATED OUTPUT FROM THE MANUFACTURING FILE CONSISTS OF MATERIAL REQUISITIONS FOR EACH FIRST USER, TRADE WORK INSTRUCTIONS AT THE WORKING LEVEL, BILL OF MATERIALS AND STAGING LISTS, AND REPORTS FOR PLANNING AND STATUSING.

GEOMETRY FILE



THE GEOMETRY FILE IS LOADED IN SEVERAL WAYS DEPENDING ON THE COMPLEXITY OF THE PART. THE LARGEST INPUT IS PRESENTLY BY BATCH AND IS PROCESSED THROUGH THE AUTOKON LANGUAGE. IN ADDITION, GRAPHICS TERMINALS ARE USED TO INITIATE NEW WORK OR FOR MAKING CHANGES TO EXISTING PARTS. AS PARTS ARE VALIDATED, THEY ARE TRANSFERRED FROM THE WORKING FILE INTO PERMANENT STORAGE.

WHEN NESTING IS TO BE DONE, A REQUEST IS MADE THROUGH THE SELECTION MODULE. THE DATA FROM THE MANUFACTURING FILE IS ANALYZED, ELIGIBLE PARTS ARE SELECTED, AND A TRANSFER IS INITIATED TO THE NESTING SYSTEM.

THIS SYSTEM HAS ITS OWN WORKING FILE AND USES TWO GRAPHICS TERMINALS. IT OUTPUTS REPORTS AND TAPES TO DRIVE NUMERICALLY CONTROLED FLAME CUTTERS.

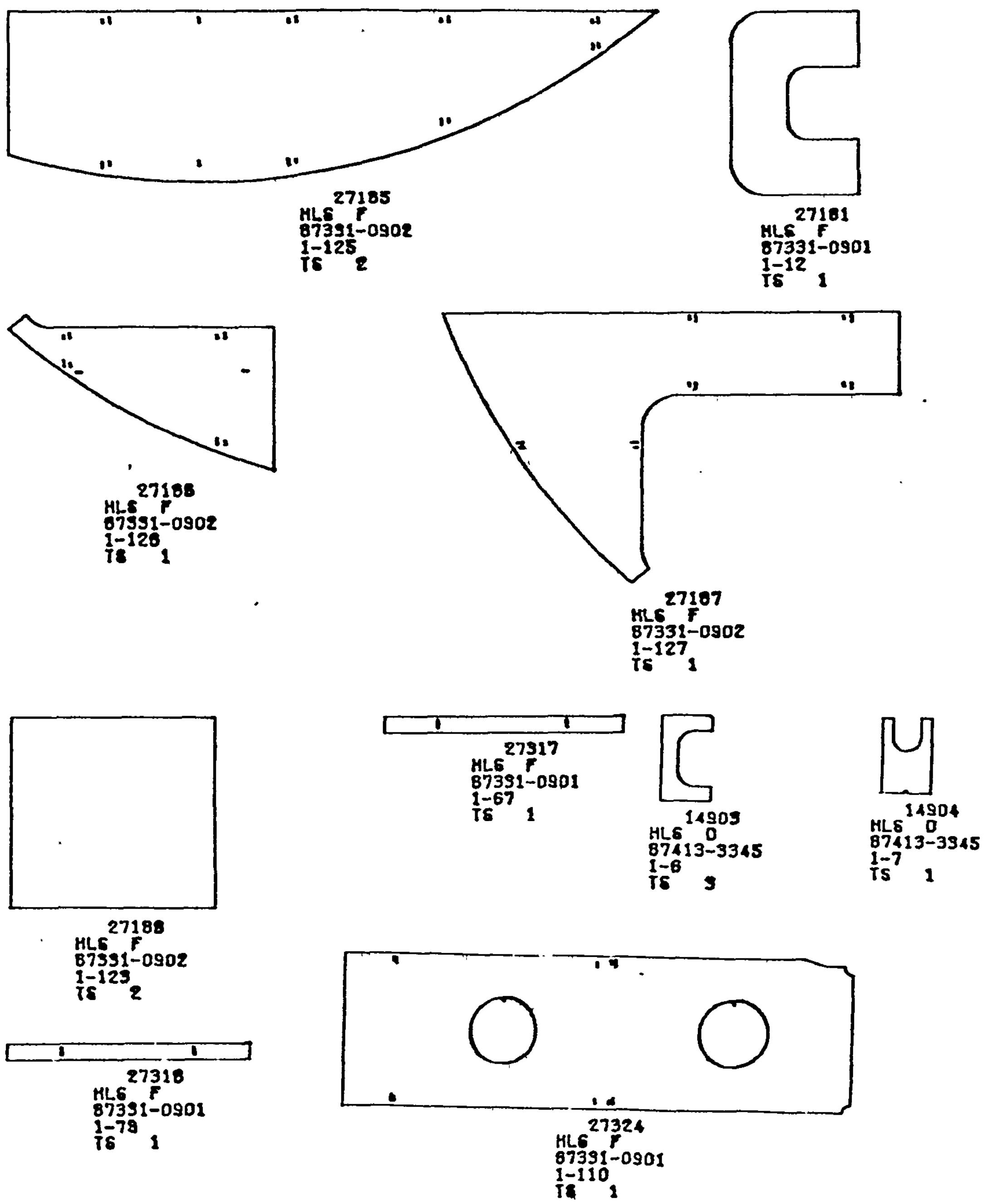
THE BALANCE OF THIS PRESENTATION IS BEING GIVEN BY MR. PAUL COFONI. HE WILL DISCUSS THE INTERACTIVE NESTING SYSTEM IN MORE DETAIL AND ALSO WILL TALK ABOUT PLANNED FUTURE ENHANCEMENTS FOR OUR STRUCTURAL CAD/CAM.

IN PARTING, LET ME MENTION THAT SOME SPECIAL CONSIDERATIONS WERE GIVEN TO THE TYPE OF PERSON BEST SUITED TO TAKE FULL ADVANTAGE OF OUR HIGHLY INTERACTIVE NESTING SYSTEM. AFTER SOME DILIGENT RESEARCH AND EXAMINATION OF SPECIFICATIONS, OUR INDUSTRIAL RELATIONS DEPARTMENT CAME UP WITH THIS ARTISTS CONCEPTION OF THE PERFECT CANIDATE . . . .

BY MAINTAINING WITHIN THE MANUFACTURING PLANNING FILES REFERENCES TO THE AUTOKON GEOMETRY FILES, PARTS REQUIRED FOR NESTING WITHIN A GIVEN PERIOD ARE AUTOMATICALLY RETRIEVED AND TRANSFERRED VIA TELECOMMUNICATIONS FROM NORWICH, CONNECTICUT TO QUONSET POINT, RHODE ISLAND, WHERE THEY ARE STORED IN THE NESTING SYSTEM'S WORKING FILES. SIMULTAN-EOUS TO TRANSFER, THE SELECTED PARTS ARE SORTED BY MATERIAL TYPE AND THICKNESS AND A PICTORIAL BOOKLET IS PREPARED FROM A NEUTRAL GRAPHICS FILE ON DRUM OR FLATBED PLOTTER OR ON STORAGE TUBE DEVICES. INFORMATION SUCH AS PART IDENTIFICATION, ENGINEERING DRAWING NUMBER AND THE PARTS LOCATION AND QUANTITY ARE DISPLAYED BENEATH EACH PART. THIS BOOKLET IS USED BY THE NESTER FOR PLANNIHG OF HIS INTERACTIVE SESSION.

NESTING ITSELF BEGINS WITH THE NESTER TAKING ADVANTAGE STATE-OF-THE-ART INTERACTIVE GRAPHICS. THE HARDWARE SELECTED IS MANUFACTURED BY ADAGE CORPORATION AND CONSISTS OF A MINICOMPUTER USED PRIMARILY FOR DATA MANAGEMENT AND TELECOMMUNICATIONS, A DISK DRIVE FOR DATA STORAGE, AN ELECTROSTATIC PRINTER-PLOTTER FOR QUICK PLOTTING CAPABILITIES, AND A MICROPROCESSOR USED TO CONTROL TWO GRAPHICS WORKSTATION. EACH WORKSTATION CONSISTS OF A REFRESH VECTOR DISPLAY SCREEN WITH 8K BY 8K RESOLUTION, ALPHANUMERIC KEYBOARD, DIGITIZING TABLET AND STYLUS, 32 FUNCTION SWITCHES, 6 VARIABLE CONTROL DIALS AND TWO FOOT PEDALS. THE APPLICATION SOFTWARE WAS DEVELOPED BY AH ITALIAN SHIPYARD. ITALCANTIERI AND REPRESENTS OVER 12 MAN-YEARS OF EFFORT BY THAT COMPANY.

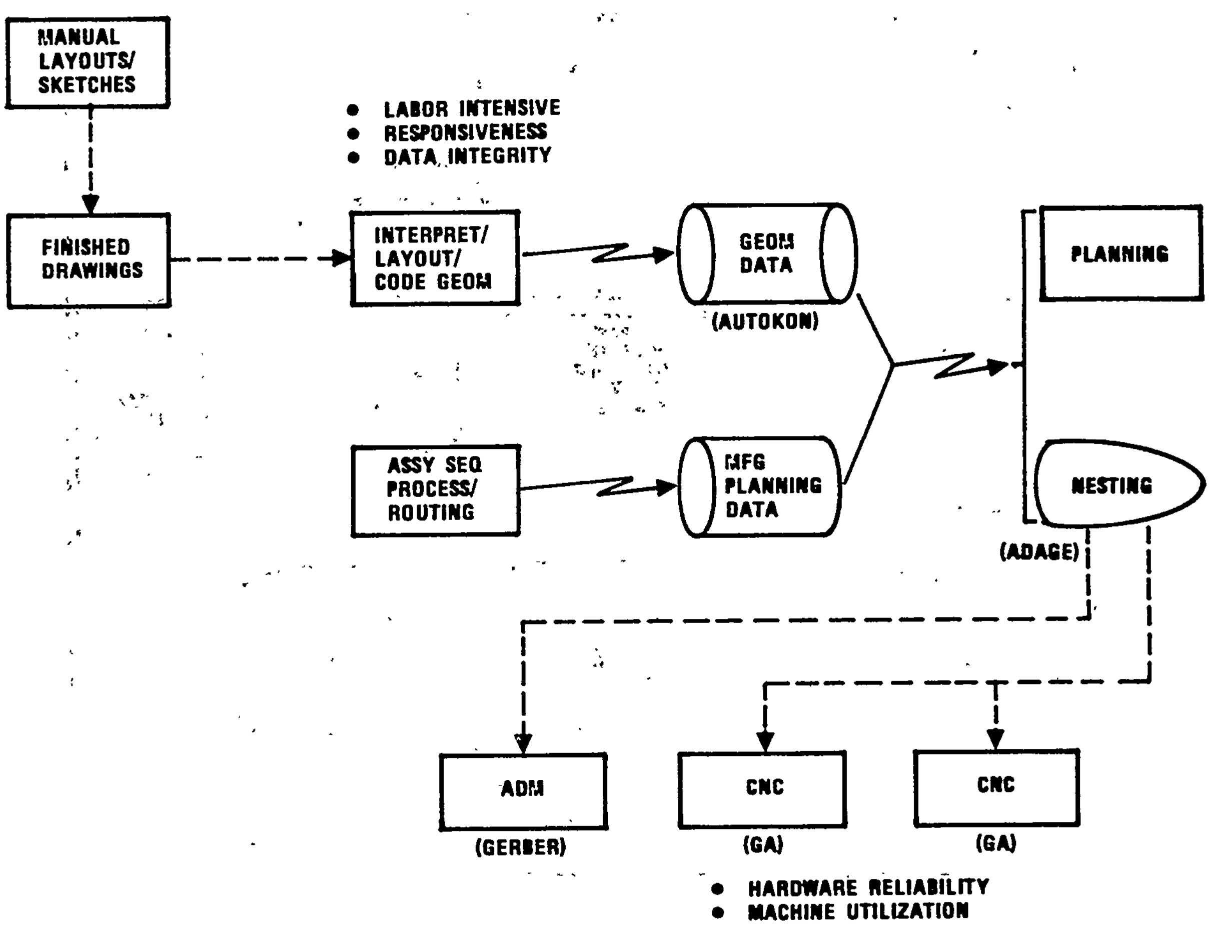
JOB 0.7261	BATCH 42	15.08.79	PAG N. 10
THIC.1.500	TYPE HY80	SOURCE: 21-94-1508	



TAKING ADVANTAGE OF THE SYSTEM'S HIGH RESPONSIVENESS AND VERSATILLTY IN THE MANIPULATION OF GEOMETRY, THE NESTER POSITIONS PARTS AND DEFINES CUTTING PATHS AND EDGE PREPARATIONS. WITH THE INCREASED SPEED OF NESTING, MANY VARIATIONS OF NEST FORMATS CAN BE ATTEMPTED IN A MATTER OF MINUTES, PROVIDING AN OPPORTUNITY TO SELECT THE BEST NEST FORMAT BASED ON PLATE AND BURNING MACHING UTILIZATION.

THE SYSTEMS ABILITY TO AUTOMATICALLY MEASURE PART POSITIONAL DATA ELIMINATES ERRORS COMMONLY ASSOCIATED WITH MANUAL MEASUREMENT, DATA TRANSCRIPTION AND KEYPUNCHING. AUTOMATIC PART INTERFERENCE DETECTION REDUCES THE NEED FOR CLOSE VISUAL INSPECTION AND CONTINUOUS MDNITORING AND DISPLAY OF PLATE UTILIZATION PERCENTAGES PROVIDES MANAGEMENT INFORMATION TO AID IN CONTROLLING SCRAP RATES. THE INTERACTION BETWEEN MAN AND MACHINE CAPITALIZES ON THE JUDGEMENT, EXPERIENCE, AND TALENTS OF THE INDIVIDUAL AND THE SPEED OF THE COMPUTER. THE ABILITY TO DO EASILY, WHAT BEFORE WAS TEDIOUS, WITH IMPROVEMENT TO THE PRODUCT QUALITY SERVES AS POSITIVE MOTIVATION FOR THE NESTER AND FOSTERS EXCELLENCE IN INDIVIDUAL PERFORMANCE.

STEEL PROCESSING



TODAY AT THE ELECTRIC BOAT DIVISION OF GENERAL DYNAMICS, STRUCTURAL DESIGN LAYOUTS, SKETCHES AND FINISHED CONTRACT DRAWINGS ARE PRODUCED USING TRADITIONAL MANUAL DRAFTING TECHNIQUES. AS PARTS ARE REQUIRED BY MANUFACTURING THE GEOMETRY OF THE PARTS ARE INTERPRETED FROM THE FINISHED DRAWINGS AND LOADED INTO GEOMETRY FILES IN SUPPORT OF NESTING FOR AUTOMATED BURNING OPERATIONS. THE MEDIA USED FOR AUTOMATED BURNING DATA IS PAPER TAPE.

A PROJECT WHICH WILL BE IMPLEMENTED AND IN PRODUCTION BY THE END OF THIS YEAR IS THE INTEGRATION OF AND INTER-ACTIVE GRAPHICS SYSTEM FOR STRUCTURAL DESIGN/DRAFTING. THE SYSTEM WILL SUPPORT 10 PRODUCTION WORKSTATIONS FOR DESIGN/DRAFTING OPERATIONS. IT WILL PRODUCE AS ITS PRIMARY PRODUCT FINISHED CONTRACT DRAWINGS USING A HIGH SPEED PLOTTING DEVICE. THE SYSTEM WILL BE INTEGRATED WITH THE AUTOKON STRUCTURAL SYSTEM TO PROVIDE FOR TRANS-MITTAL OF GEOMETRY TO THE MANUFACTURING DATA BASE, AS THE GEOMETRY IS DEFINED DURING THE DESIGN PHASE. THE SYSTEM WILL INCREASE PRODUCTIVITY DURING BOTH SUBMARINE DESIGN AND MANUFACTURING, AND WILL SHORTEN LEAD TIMES BETWEEN PRELIMINARY DESIGN AND DETAILED DESIGN AND MANUFACTURING.

THIS WILL BE ACCOMPLISHED BY; REPLACING MANUAL DRAFTING WITH AUTOMATED DRAFTING; BY CAPTURING STRUCTURAL GEOMETRY AT THE TIME IT IS DEFINED INITIALLY IN A COMPUTER DATA BASE; AND BY PROVIDING DETAILED GEOMETRY TO MANUFACTURING PERSONNEL SAVING THEM BOTH DRAWING INTERPRETATION AND PART CODING TIME.

ANOTHER PROJECT PROPOSED FOR THE 1980 IS THE IMPLEMENTATION OF DIRECT NUMERICAL CONTROL/COMPUTERIZED NUMERICAL CONTROL SYSTEMS FOR AUTOMATED BURNING AND WELDING OPERATIONS. THE DNC/CNC SYSTEMS WOULD REPLACE PAPER TAPE WITH HIGH SPEED COMMUNICATION LINES WITH PAPER TAPE AS A BACKUP INPUT MEDIA. THE SYSTEM WILL BE FULLY INTEGRATED WITH THE ADAGE NESTING SYSTEM, SO THAT FINISHED NEST FORMATS CAN BE ROUTED DIRECTLY FROM THE NESTING OPERATIONS

TO BURNING OPERATIONS WITH MINIMAL MANUAL INTERVENTION. THIS PROJECT WILL PREVENT A SINGLE SOURCE OF FAILURE WITHIN BURNING/WELDING OPERATIONS AND WILL INCREASE THROUGHPUT ON THE AUTOMATED MACHINERY BY REDUCTION OF SET-UP TIME.

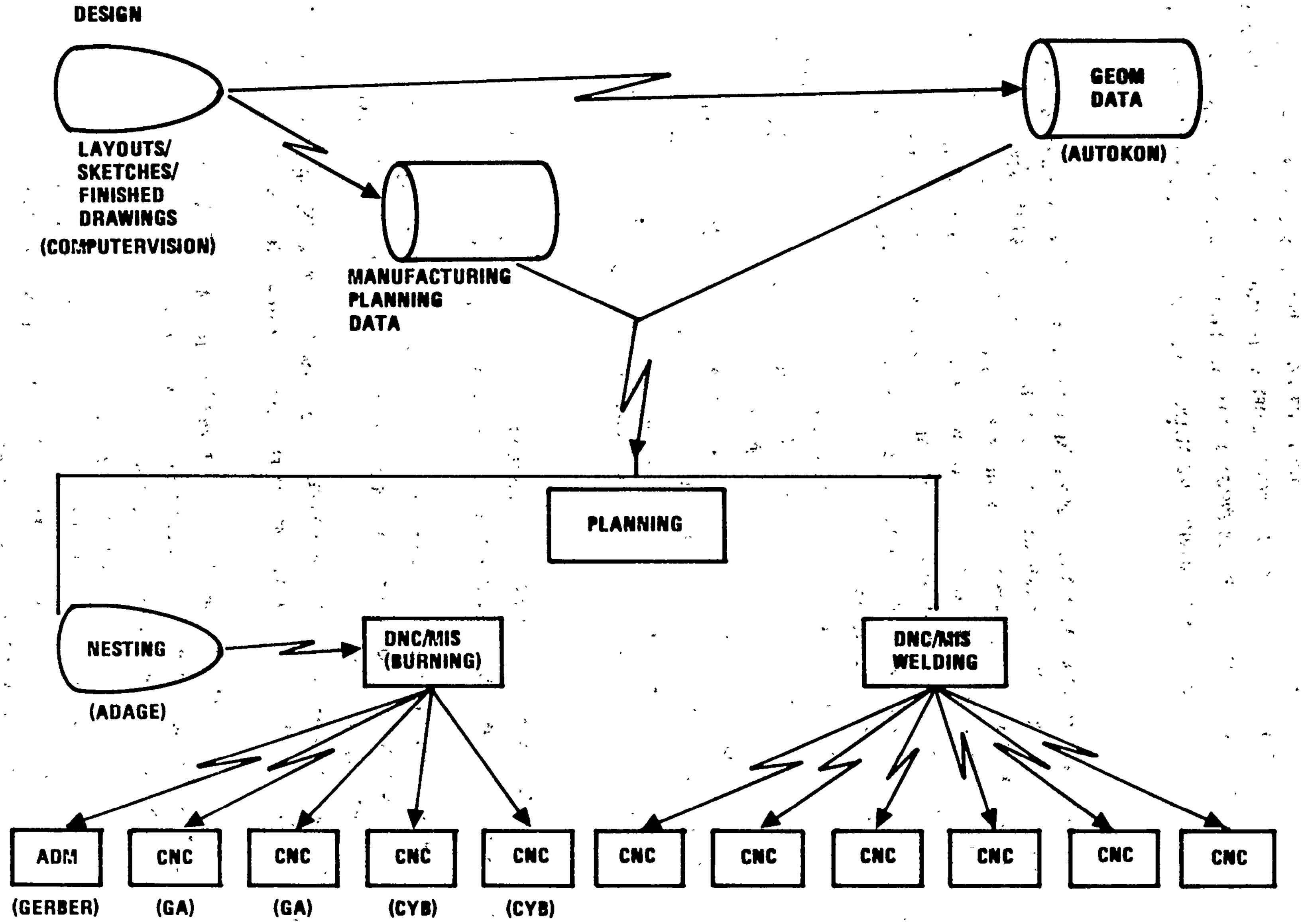
UPON COMPLETION OF THIS PROJECT THE STRUCTURAL DISCIPLINE AT THE ELECTRIC BOAT WILL BE ONE AUTOMATED AND INTEGRATED SYSTEM CAPITALIZING ON AUTOMATED INPUT AND OUTPUT OF DATA, EARLY AVAILABILITY OF THE DATA, AND REDUCED MANUAL INTERVENTION IN THE COMMUNICATION OF THE DATA.

THE WORD INTEGRATION HAS BEEN THE CORNERSTONE IN OUR STRUCTURAL CAD/CAM PLANNING. WHILE IMPLEMENTATION OF NEW TECHNOLOGIES ON THEIR OWN MERITS CAN BE JUSTIFIED, A LARGER PAYBACK IS SEEN IN INTEGRATING THESE TECHNOLOGIES INTO THE EXISTING SYSTEMS.

IN THE CASE OF DESIGN/DRAFTING, INTERACTIVE GRAPHICS INCREASES PRODUCTIVITY IN THE PREPARATION OF CONTRACT DRAWINGS, BUT BY INTEGRATING THE SYSTEM WITH MANUFACTURING GEOMETRY FILES, A BY PRODUCT OF THE DESIGN EFFORT BECOMES EARLY AVAILABILITY OF MANUFACTURING GEOMETRY AT REDUCED COST.

IN THE CASE OF STEEL PLATE NESTING, INTERACTIVE GRAPHICS INCREASES PRODUCTIVITY IN NESTING ITSELF BUT BY INTEGRATING THE SYSTEM TO THE EXISTING MANUFACTURING PLANNING FILES IT IS POSSIBLE TO ACCOMPLISH FULL PLATE NESTING, REDUCED MATERIAL HANDLING AND STORAGE AND HIGHPLATE UTILIZATION. AND SO INTEGRATION PROVIDES A CASCADING OF BENEFITS, AND THE JUSTIFICATION FOR IMPLEMENTING HIGHER TECHNOLOGIES BECOMES A SYSTEM JUSTIFICATION FOR A WAY OF DOING BUSINESS.

STEEL PROCESSING



COST-EFFECTIVE N/C PROCESSING IN A SMALL SHIPYARD

William Shipley
Vice-President of Engineering
Marinette Marine Corporation

As Vice-President of Engineering, Mr. Shipley is in charge of the estimating, design, and production engineering functions to support new vessel construction. He has a degree in civil engineering from Montana State University and has held the positions of Engineering Department Head, Planning and Scheduling Manager, and Project Engineer at Marinette Marine Corporation.

Filippo Cali
President
Cali and Associates Incorporated
New Orleans, Louisiana

Since the founding of Cali and Associates Inc, Mr. Cali has directed the continuous development of the SPADES system, and expanded the company to provide complete N/C lofting services to the shipbuilding industry, with particular emphasis to the small and medium size shipyards. He has an engineering degree from the Italian Naval Academy.

Mr. Cali has over 30 years experience in all phases of shipbuilding. Prior to founding Cali and Associates, Mr. Cali held the positions of Vice-President for Engineering at Avondale Shipyards, and Director of Engineering at Litton Ship Systems.

PART I - The Shipyard's Viewpoint by W. D. Shipley, Vice President Engineering, Marinette Marine Corporation

INTRODUCTION

My role here is to present the rationale behind the shipyard's recent decision to upgrade its N/C burning facilities and develop inhouse programming capabilities. Credits for developing and implementing the proposed changes belong to Jim Wilson in the Engineering Department at Marinette Marine Corporation (MMC) and Filippo Cali of Cali and Associates (Cali) who spent many hours researching the alternative ways of generating and transmitting N/C images for shipyard use. In addition, Russel Morgan and Douglas Gifford of the Linde Division of Union Carbide as well as Duane Holloway of Calcomp must be recognized for their active support to provide the necessary software and hardware against a tight schedule once a "GO" decision was made.

BACKGROUND

MMC began N/C burning in 1971 with the acquisition of the first production unit (Serial No. 1) of Linde Model CM100, with gas torches, and paper tape controls. The first tapes were purchased from Cali who has been our N/C source on all programs since, with two exceptions. The original burning machine was later upgraded to cut with plasma-arc as well as gas. In 1978 MMC purchased a second burning center, Linde Model CM150, with plasma and gas torches, and dual mode controls to accept either paper tapes or direct numerical-control commands.

The shipyard has realized greatly improved burning efficiencies with the combination of N/C controls and plasma torches. However, the optimization of the burning process created a new set of problems

which neither the shipyard nor Cali was willing to accept as the price of progress. Two basic problems associated with the process of generating and transmitting paper tapes were recognized:

1. <u>SCHEDULE PROBLEMS</u>

   Lead times to produce N/C parts after contract award were often greater than the old manual methods, resulting in schedule slippages for all trades paced by steelwork. In addition, the turn-around time to make tape changes was excessive due mostly to mailing time between Cali & MMC. These changes, usually initiated by the shipyard, disrupted Cali's staff with unscheduled overloads.

2. <u>COST PROBLEMS</u>

   The high costs for making unscheduled tape changes were passed on to the shipyard. In addition, the material cost along for high quality paper tapes was excessive. A recent cost study indicates that the shipyard would save roughly $32,000.00 per year at current production levels by eliminating paper tapes as the N/C control medium.

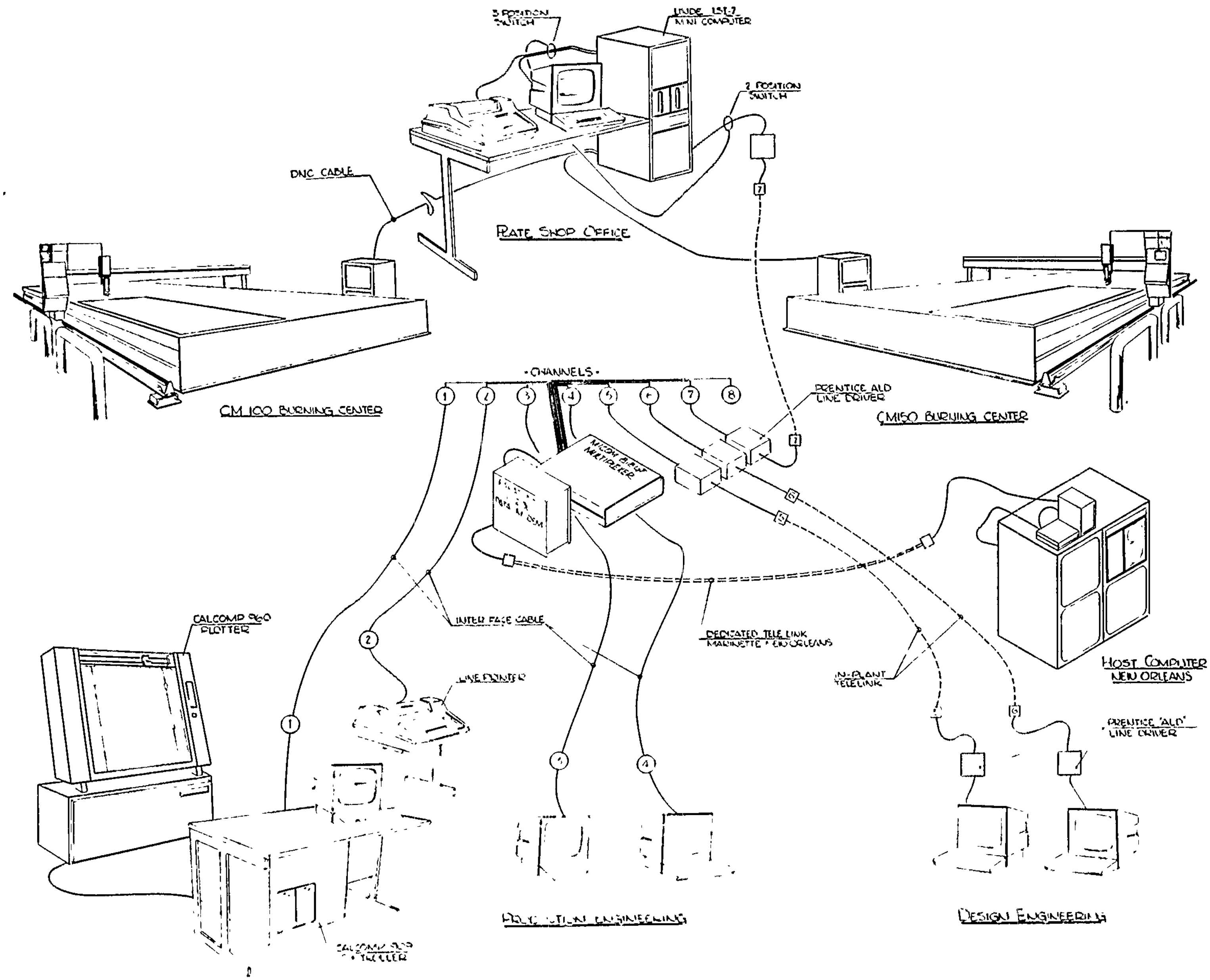
As a result of identifying these problems, it was concluded that the shipyard must develop greater control over the schedules and costs of generating N/C programs. Two goals were proposed and adopted for further study:

1. Convert the burning machine controls from paper tape to DNC mode with direct telecommunication between the burning machine and the host computer to minimize transmission delays between Cali and MMC and to also eliminate paper tape material costs. This change was easily justified as both schedule and cost effective on its own merits.

2. Develop the capability within the shipyard to ultimately perform all N/C programming inhouse. This goal was highly constrained by a tight capital equipment budget and the difficulty of recruiting and training programmers. After considerable "brainstorming" between Cali and MMC people, it was concluded that a two-phase approach was the optimum solution. The first phase, now being implemented, would give the shipyard the inhouse capability to plot, verify, and nest parts generated and transmitted by Cali directly to the shipyard over a dedicated telecommunication line. The second phase would add the capability to generate parts inhouse after Cali's new Interactive Graphics System was fully developed and proven.

STATUS

Both proposals (convert to DNC and add partial programming capability) were approved on May 16 this year. The plotter was on line with Cali by June 23 and the first part images were transmitted on July 7. The DNC conversion and checkout is on schedule for completion by september 30, 1979. The shipyard's Management is impressed and pleased with the rapid progress made to implement-the adopted changes. Details of the system will be covered in the second part of this paper. Finally, MMC intends to further utilize the new hardware in the near future with the addition of ship design software modules..


3 POSITION SWITCH
LINDE LSI-2 MINI COMPUTER
2 POSITION SWITCH
DNC CABLE
PLATE SHOP OFFICE
CM 100 BURNING CENTER
CM150 BURNING CENTER
CHANNELS
PRENTICE ALD LINE DRIVER
CALCOMP 960 PLOTTER
INTER FACE CABLE
DEDICATED TELE LINK
LINE PRINTER
IN-PLANT TELELINK
HOST COMPUTER NEW ORLEANS
PRENTICE 'ALD' LINE DRIVER
DESIGN ENGINEERING

PART II - Technical Development and Hardware by Filippo Cali, President, Cali and Associates, Inc.

Background History of the Development

In order to present the technical side of Marinette Marine's Installation I think it is proper to review the past events that led to it. It was in 1976 that Cali & Associates developed, jointly with Avondale Shipyards, the interactive graphics version of the Spades System. A paper on the subject was presented and a movie shown at the 1976 Reaps Symposium. While this software has been used successfully by Avondale, the requirement of a large IBM/370 Main Frame and expensive IBM 2250 CRT's has prevented us to use it in the course of our N/C service work or to make it available to any other Spades user.

During the fall of 1978 we started looking for alternatives that would allow us to continue Interactive Graphics Development and not require a large capital investment in hardware. The present I/G version of Spades includes:

- Part generation
- Nesting
- Shell Development
- Data Base access and display

It is our intention to further improve the nesting by combing with it an automatic nesting capability utilizing the Bill of Material, Modules Breakdown and N/C information collected by the "SPAC" (Shipbuilding Production and Control) module of Spades.

The other area that needs development is the generation of 2 dimensional drawings for engineering and 3-D (isometric) drawings for production using graphic CRT's.

In December we selected the host computer we wanted to use and we placed an order with Prime Computers for the following hardware:

P	400 CPU with 1 Megabyte Core	
2	300 Megabytes Disk Drives (Removable packs)	
1	Mag Tape Drive (800/1600 BPI)	
1	600 LPM printer	
1	300 CPM Card Reader	
2	Bisynchronous Ports	
16	Asynchronous Ports	
4	80 Character Alphanumeric CRT's	
1	132 Character Alphanumeric CRT (VT 100)	ADDED
1	150 Characters Per Second Teleprinter (T.I. Omni 800)	LATER

A tentative selection was also made for the graphic CRT's, but the order for two 3205 IMLAC's was not placed until July this year since we would not have had the resources for the conversion and further development of the graphic software until completion of the equivalent task with the standard batch version of Spades.

The "Prime" computer was installed on February 1, and by April 1, the conversion and checkout of "Spades" and Data Base Conversion Program was complete.

Even though many changes were necessary, they were made in such a way to maintain total compatibility with the "IBM" version used by all other "Spades" users. This was essential in view of our committment to release yearly the current version of "Spades" with all latest improvements to all users at no cost. It goes without saying it that we make sure the implementation of each release is totally transparent to the user, i.e. "Spades '80'" is totally compatible with Data Bases and input data generated with "Spades '70'".

The program to convert the binary Data Base works both ways from "IBM" to "Prime" and vice versa. That is we generate, using the "Prime" computer, an "IBM" compatible mag-tape to be read directly into a "Spades" "IBM" Data Base.

Since April, when we switched to "Prime", we have concentrated our effort to improve our operation efficiency in that environment, with two broad goals in mind:

- Easy access and use of the system through the various alphanumeric "CRT's"
- On line access and display of the Data Base for all data suitable for alphanumeric display.

During this period the possibility of remote entry and "DNC" (Direct Numerical Control) became more real than in the past. This subject had been discussed many times with Marinette but always postponed because of the capital cost of the hardware and cumbersome software (RJE, HASP, etc.)

Even with the "Prime", which can host a 2780 terminal, our first approach was again the conventional remote entry with enough hardware at the remote site to handle the numerous communications with the host needed in a shipyard using numerical control in a "DNC" mode. Of course, this alternative preluded totally in line access to the Data Base for both alphanumeric and graphic CRT'S. While looking for communication equipment, we became aware that both cost and availability of hardware had improved to the point where a totally different alternative was possible. Additional software would be needed in the "Prime" to handle the plotter and the burning machine, but the increased flexibility and reduced cost at the shipyard made it worthwhile.

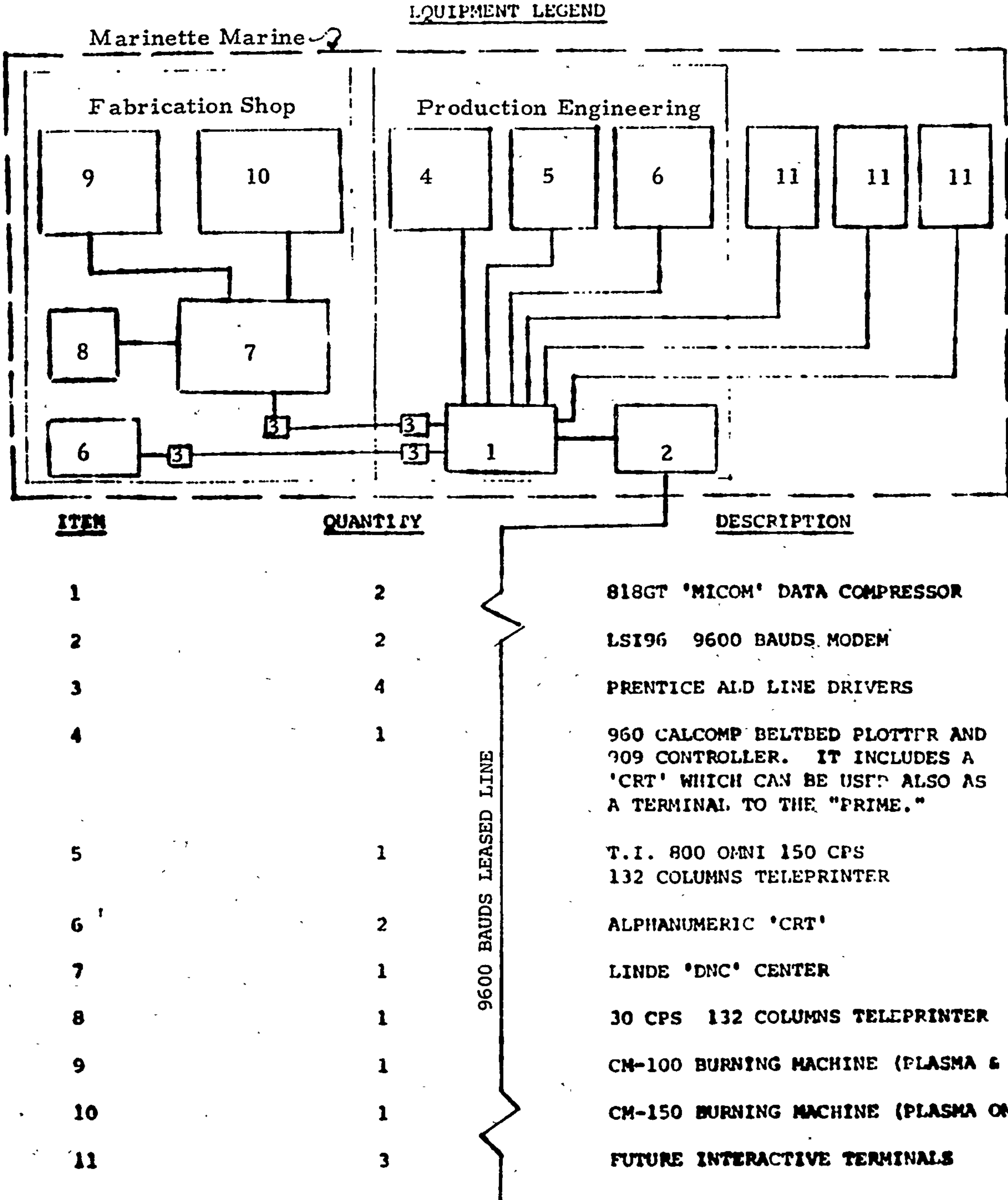
This alternative was discussed with Marinette Marine and at the end of May their management decided to go ahead with it. By the end of June, communication was established to access the "Prime" and drive the Calcomp plotter. Following is a detailed description of the entire installation.

Detailed Description

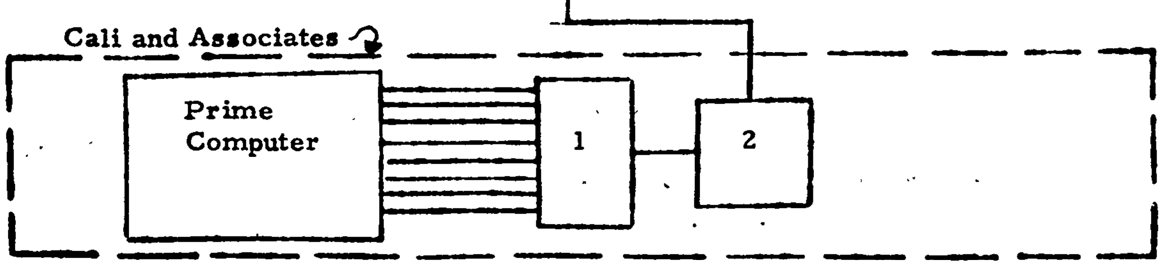
Fig. (A) shows all components. All devices at the shipyard, in so far as the user is concerned, are at all times in direct and independent communication with the host. Each one is "TTY" compatible and uses an Asynchronous Line.

Figure A

EQUIPMENT LEGEND



ITEM	QUANTITY	DESCRIPTION
1	2	818GT 'MICOM' DATA COMPRESSOR
2	2	LSI96 9600 BAUDS MODEM
3	4	PRENTICE AID LINE DRIVERS
4	1	960 CALCOMP BELTBED PLOTTER AND 909 CONTROLLER. IT INCLUDES A 'CRT' WHICH CAN BE USED ALSO AS A TERMINAL TO THE "PRIME."
5	1	T.I. 800 OMNI 150 CPS 132 COLUMNS TELEPRINTER
6	2	ALPHANUMERIC 'CRT'
7	1	LINDE 'DNC' CENTER
8	1	30 CPS 132 COLUMNS TELEPRINTER
9	1	CM-100 BURNING MACHINE (PLASMA & GAS)
10	1	CM-150 BURNING MACHINE (PLASMA ONLY)
11	3	FUTURE INTERACTIVE TERMINALS



All lines go through the Micom 818GT Data Compressor which packs all data for synchronous transmission through the Paradyne Modem at 9600 Bauds accross a four wires dedicated line from the shipyard to our offices in New Orleans. A matching set of Modem and Micom reverses the packing and distributes all data to the corresponding eight Asynchronous Lines going to the "AMLC."

The advantages of this approach can easily be appreciated when we consider the following sample list of communications with the "Prime" being handled simultaneously:

1. In the burning machine shop the LINDE 'DNC' Center is receiving and storing in floppy disks N/C tape images to be routed to either of the two burning aachines.
2. Still in the shop the 'CRT' is being used to request additional tape images from the "Spades" Data Base or perhaps request a tape image for a single piece, part of a previously cut nested plate, that has been misplaced, damaged, or affected by design changes.
3. In the Production Engineering Department the Calcomp plotter is receiving plotting data to either plot directly or store on floppy's for later plotting.
4. In the Production Engineering Department another 'CRT' is being used to enter input data for execution by "Spades." This function not only replaces the traditional keypunch, but stores the data at the same time in the "Prime."
5. In the Production Engineering Department another 'CRT' is being used for any other miscellaneous task such as:

    - Execution of any "Spades" module
    - Requesting additional plotting files for the Calcomp plotter
    - Accessing the "Spades" Data Base in real time to display and check data or to enter data such as recording the validation of a part or putting under hold a burning machine tape image affected by drawing changes.

6. In the Production Engineering Department the printer is receiving hard copy of title blocks and processing time associated with nested tape images to be released.
7. In production control, a 'CRT' is being used to access "SPAC" to check the status of lofting for a construction module or perhaps to extract the corresponding Bill of Material.
8. In the Design Engineering Department a 'CRT' is in use to enter data and generate hydrostatic curves, damaged stability tank capacity and sounding tables, etc.

The advantages of the above capability over that of a conventional remote batch entry are obvious enough to not require any further elaboration.

The baud rate presently assigned to each of the channels is 1200 with the exception of the calcomp plotter which uses 4800 baud's. This distribution is more than adequate when we consider the human speed at each terminal and the buffering and "No Dead Air" capability of the 818GT Micom. Marinette's plans for the near future call for the use of the interactive graphic version of "Spades." I would assume at this time that a four channels installation similar to one above will be required with each channel rated at 4800 bauds. In order to better support both our own and remote graphic terminals we have already scheduled the upgrading in the first quarter of next year, of our CPU from the "400" to a "750."

Supporting Software

To make the Marinette installation a practical reality, a considerable amount of supporting software had to be conceived, developed, and implemented:

- Spooling programs to handle communication and transmit data to the burning machines and to the plotter with the appropriate protocol each required.
- The generalized "Spades" post-processor had to be modified to include the Calcomp. This is one of the instances when the modular structure of the "Spades" system has paid off handsomely. By changing 'the post-processor all "Spades" modules with graphic outup acquired the Calcomp option, whether to plot a set of curves of form or a nested tape image.
- All procedures for execution of Spades both batch type or interactive had to be modified to recognize each user and check the right of the user to access any of the ships in the Data Base. That is, Marinette can only access Marinette jobs.
  The "Spades" output also had to be screened to insure compatibility with the receiving device, i. e.
  - The burning machine should only receive data in the format required by the LCNC-6 and UCNC controllers.
  - The Calcomp Should receive only Calcomp plotting data.
  - Form control for the printer has to be the appropriate for that type vs. the conventional 600 LPM printer at our office.

The development of this software required in some cases a considerable amount of adaption on our part. For instance the "909" controller of the plotter does not allow at the present storing more than one plot file in any one disk. To accept this limitation, it would have meant a continuous changing and storing of floppies. Instead, the spooler was designed to keep the plot file open and accumulate all the separate drawings in one single plot file, that would be closed only at user's request. This, of course, imposed the necessity of creating Calcomp search addresses (pointers within the plot file), associating them with the user's drawings' names and recording them for future reference to the user when plotting in a random sequence from the plot file.

As a further aid to the operator of the plotter, changes were made to "Spades" System that cause a stop at the beginning of each logical drawing and display a message on the 'CRT' stating X & Y dimensions in inches required by the drawing. If the "Spades" system finds the area required by the drawing to be larger than the maximum for the plotter the scale is automatically reduced and a message displayed to the operator.

This last feature is now part of the system for all installations whether or not operating in a "DNC" mode. The only difference being that the message is written on the drafting machine through the paper tape itself.

Closing Remarks

The entire development described above would have not materialized without Marinette Marine's tradition to commit to new technology without waiting to be proven first somwhere else.

I would like also to take this opportunity to point out that, as in the past for all "Spades" developments, this also was accomplished with financing from the private industry without any government grant and associated red tape. The April to July time span from conception to implementation of this project offers in itself the best proof of the cost effectiveness of the free enterprise approach vs. government financing.

AUTOKON-76/79 - AN AFFORDABAE IMPLEMENTATION ON PRIME MINICOMPUTERS

Jon Gude
Senior Consultant
Shipping Research Services Inc
Houston, Texas

Mr. Gude is presently involved in converting AUTOKON-79 to run on PRIME computers. He has a degree in naval architecture and shipbuilding from the University of Durham in England, and a masters degree in economics from the University of Delaware.

He has previously held the positions of Office Manager at a Norwegian shipping company, and Project Manager at Sun Shipbuilding and Dry Dock Company.

AUTOKON - 76/79, AN AFFORDABLE IMPLEMENTATION ON PRlME MINI COMPUTERS

The version that is about to be implemented on the PRlME mini computer is basically AUTOKON-79 which may be defined as AUTOKON-76 with some improvements as well as several major new features.

The very rapid development of the computer industry with steadily falling prices have changed the outlook with respect to computers and their uses. It is presently feasible to use inhouse computers even for very small operations to run the entire AUTOKON system with its present capabilities as well as the developments that *are* about to be implemented.

The traditional way of processing in a batch made with a waiting time for turnaround have given way to an interactive mode of processing where results come much sooner. Gone are also keypunching, job submission, etc. No longer is it necessary to have large number of pages printed out. Output can be examined by means of an editor, i.e. a system program enabling the user to go through print files as well as other files. Similarly, by means of a graphic scope it is possible to *review* graphic output without drafting.

The most important aspect of these rapid changes is the cost reduction. It is now within reach of all shipbuilders to run AUTOKON on a mini computer such as the PRlME. This computer may well be dedicated to engineering. In fact it may be advantageous to use a dedicated computer.

While computers become more capable and cheaper, the AUTOKON system has been improved and expanded considerably. It has also become more cost effective. Some of these new features utilize the graphic scope such as the TEKTRONIX 4014. But there are other new features.

Apart from the reasons outlined above, the possibility of running interactive graphics was a major consideration in suggesting a dedicated mini computer. It is presently possible to run interactive graphics on an outside computer, but it *is* far better to use an inhouse computer. The major reasons for this are line speed as well as susceptibility to telephone problems which do occur.

A typical configuration could be as follows:

P550 Base System 512 Kbyte
Disk, 96 Mbyte with controller
Tape Unit, 800 BPI with controller
Line Printer, 300 LPM
Paper Tape Reader/Punch
Two ALPHA Numeric Scopes

Total Purchase Price $141,000

Lease price for 5 year period 2.4% of total price per month.

For above installation	$3,385
Monthly Maintenance, Approx.	1,100
Monthly Cost, Approx.	$4,500

It would be possible to run with a memory of 256 K byte but for practical reasons 512 K bytes seems right and it appears that future extensions to the operating system will require 512 K bytes.

It is also possible *to* operate without a tape drive, but it is really required when backing the system up as well as for putting up new software.

The configuration above includes only two scopes, as many as 14 more, a total of 16 may be put on without putting an extra controller. However, an on-line drafting machine as well as TEKTRONIX graphic scopes each would occupy one of the available terminal lines.

An AUTOKON user would also require a plotter and it is suggested that a CAPCOMP 1038 with a 906 interface be used. This is supported by PRlME and "looks" like a terminal to the computer itself.

Typical prices are presently as follows:

CALCOMP 1038	$9,900
CALCOMP 906	3,324
	$13,224

On a two year lease with maintenance the monthly charge would be approximately $675. However, for shipyards that already has a drafting machine this cost indicated here should be neglected for comparison reasons.

It would have been possible to use other minis besides PRlME. However, the PRlME was chosen for these reasons:

- proven performance of AUTOKON-71 processing by Todd Shipyards.
- one of the lowest priced suitable computers with 32 bit word length.
- 32 M bytes of virtual memory.
- well proven, user oriented operating system and FORTRAN compiler,
- designed for scientific and interactive applications.
- manufacturer is interested in end users, like small shipyards.
- international sales and support organization.
- without changing operating system the user can upgrade his computer from a P 550 to a more powerful P 650 and P 750 configurations.
- several prime CPU's can communicate with each other (large users through established communication procedures,
- ease of communicating with other main frames.

This basic configuration may be expanded depending on the usage and runs of the customer. For AUTONEST and AUTOPART a graphic scope is needed and the price of such a scope with the

TEKTRONIX 4014-1, Enhanced-Graphic Option with Hard Copy Unit	$17,600
Lease for 3 year period including maintenance, approximately	$ 700

For heavier use a customer may want to expand the PRlME systems

96 M byte without controller
Additional ALPHA NUMBERIC screens
600 lpm line printer, over 300 lpm

Total -Purchase Price $36,200

Lease, 5 years with maintenance $ 1,160

A summary of approximate monthly expenses is therefore as follows:

Basic PRlME System	$4,500
Drafting Equipment	675
Graphic Terminal	700
Additions to PRlME Systems'	1,160
T o t a l	$7,035
With 2 Graphic-Terminals	$7,735

The conversion has been performed for nearly all modules short of the BOF module that will replace FAIR, DRAW and OF-TAB. A newer version of ALKON will also be put up- shortly.

Last *year's* paper by Dennis K. Medler and Jack Harper explained the way AUTOKON-71 was converted. The conversion of the AUTOKON 76/79 has followed a similar path.

By having a dedicated computer and only paying the monthly base amounts, computing costs Will not escalate without control. PRlME's standard operating system permits scheduling of jobs by preparing job streams on a file.

Outside computer costs consist of many elements, CPU; I/O, disk file rental, tape storage and connect charges as well as possible phone or connect charges. In addition is often necessary to have an operator to run the terminal.

Equally important is the ready access to the computer facility. Where computers are shared between departments there will frequently be collisions between engineering and data processing. No run has higher priority than a payroll.

Based on what has already been practiced by PRlME users, it is safe to say that the CPU time throughout the night can be utilized while the computer itself is left unattended. This can be done by queing jobs. It is not always the case, but line printers frequently need attention.

It is not necessary to keep a staff of programmers/analysts in order to keep AUTOKON running on a dedicated mini computer. The AUTOKON maintenance is, in our opinion, best left to SRS Inc. One person must be sufficiently trained *to* start the computer, back it up and perform daily maintenance. This could well be the person who now operates the terminal.

All others need not necessarily be trained as anything else than users. As such they will experience a much faster turnaround. Some additional training may be required to take advantage of the interactive features. With a powerful computer available it seems reasonable to expect that existing non AUTOKON programs would be converted to run on the PRlME.

MINICOMPUTER APPLICATIONS FOR LONG RANGE PLANNING

Lawrence D. Eddy
Chief of Planning and Performance Analysis
National Steel and Shipbuilding Company
San Diego, California

Mr. Eddy as Chief of planning and performance analysis, is currently in charge of supervising the activities of the analysis, progressing, and operations sections within the Planning and Production Control Department.

Mr. Eddy is a graduate of San Diego State University with a degree in applied physics. His past experience includes systems analysis, cost estimating and analysis, and structures engineering.

SEVERAL YEARS AGO WE, THE PLANNING AND SCHEDULING DEPARTMENT OF NATIONAL STEEL AND SHIPBUILDING COMPANY, DECIDED TO AUTOMATE A PROCEDURE FOR ASSESSING THE SHIPYARD RESOURCES REQUIRED TO SUPPORT POTENTIAL NEW BUSINESS, THE PROCEDURE CENTERED AROUND THE USE OF "S CURVES" WHICH WERE USED TO SPREAD ROUGH-CUT ESTIMATED HOURS FOR THE POTENTIAL NEW BUSINESS OVER, THE BUILDING SPAN DURING THE ANTICIPATED TIME FRAME IN WHICH FACILITIES WOULD BE AVAILABLE, DATA WAS PRODUCED AT THE YARD LEVEL AND FOR VARIOUS CRITICAL TRADES FOR BOTH PREVIOUSLY COMMITTED WORK AND THE ANTICIPATED NEW BUSINESS, THE DYNAMICS OF THE MARKET PLACE, COUPLED WITH A MANUAL SYSTEM, MADE IT DIFFICULT TO SUPPORT MANAGEMENT WITH THIS ESSENTIAL INFORMATION IN AN EXPEDIENT MANNER,

AT THAT POINT IN TIME WE TOOK DELIVERY OF A TEKTRONIX MODEL 4051 MINICOMPUTER, IT WAS PRIMARILY SLATED FOR PERFORMING LEAST SQUARES BEST FIT REGRESSONS WHICH WERE TO BE USED IN MAKING ESTIMATES AT COMPLETION, THE USE OF THIS MINICOMPUTER AS A TOOL GAINED RAPID ACCEPTANCE WITHIN THE GROUP AND WE EAGERLY SOUGHT OTHER APPLICATIONS FOR ITS USE, THE "WHAT-IF" GAMES, AS WE CALLED THEM, SEEM LIKE THE IDEAL CANDIDATE,

IF YOU WOULD LIKE TO TAKE ADVANTAGE OF THE LONG RANGE PLANNING TECHNIQUE WHICH I'M ABOUT TO EXPLAIN TO YOU, YOU WILL HAVE TO TAKE INTO ACCOUNT THE FOLLOWING CONSIDERATIONS AS SHOWN ON FIGURE 1. WHILE WE CHOSE A TEKTRONIX MODEL FOR OUR MINICOMPUTER, THERE ARE MANY OTHER EQUALLY WELL SUITED COMPUTERS THAT CAN GET THE JOB DONE, THE TEKTRONIX MODEL 4051 IS A GRAPHIC TERMINAL WHICH HAS 32K BYTES OF PROGRAMABLE CORE, A TAPE DRIVE, AND AN AUXILIARY HARDCOPY UNIT,

LONG RANGE PLANNING CONSIDERATIONS

HARDWARE

- o TEKTRONIX MODEL 4051
- o GRAPHIC TERMINAL
- o TAPE DRIVE
- o HARDCOPY UNIT

SOFTWARE

- 0 PROGRAMMING
- 0 LANGUAGE
- 0 STATISTICAL PACKAGE

DATA

- 0 COLLECT
- 0 NORMALIZE
- 0 POLYMONIAL CURVE FIT
- 0 FAMILY OF CURVES
- 0 CONSTRUCT MATRIX

STATUS

- O PROGRESS
- O ESTIMATE TO COMPLETE
- O MODEL CURVE SELECTION
- O KEY DATES
- O BUILDING POSITION

Figure 1.

A GREAT DEAL OF CONSIDERATION MUST BE GIVEN TO THE SOFTWARE WHICH MUST BE DEVELOPED, THE COMPUTER BY ITSELF IS A DORMANT TOOL UNTIL IT IS PROGRAMED, THEREFORE, YOU OR YOUR PEOPLE WILL HAVE TO LEARN TO WRITE SIMPLE PROGRAMS, I WOULD SUGGEST THAT YOU STICK TO THE BASIC PROGRAMMING LANGUAGE SINCE IT IS INTERPRETIVE AND VERY EASY TO USE,

THE SOURCE DATA MUST BE AVAILABLE,, THIS HISTORICAL DATA COULD BE IN SEVERAL FORMS SUCH AS MEN OR HOURS PER DAY OR WEEK OR MONTH, IT MUST ACCURATELY REPRESENT HOW A SHIP WAS CONSTRUCTED OVER TIME, THE NEXT STEP IS TO NORMALIZE THE COLLECTED DATA BY REDUCING THE DEPENDENT AND INDEPENDENT VARIABLES TO SPREADING 100% OF THE RESOURCE OVER 100% OF THE TIME RESPECTIVELY, THE NORMALIZED DATA IS THEN ENTERED INTO THE COMPUTER AS A PAIRED XY DATA POINTS FILE WHERE IT IS RUN AGAINST A LEAST SQUARES BEST FIT POLYNOMIAL CURVE STATISTICAL PROGRAM UNTIL AN EQUATION OF SUITABLE FIT IS OBTAINED, THE PROCESS IS REPEATED FOR DIFFERENT TYPES OF SHIPS THAT YOU HAVE BUILT UNTIL YOU HAVE CONSTRUCTED A FAMILY OF MODEL CURVES, THESE CURVES COULD BE IN EITHER THE CUMULATIVE (REF. FIGURE 2) OR THE INCREMENTAL (REF. FIGURE 3) FORM.

ONCE THE "MODEL CURVE" LIBRARY HAS BEEN ESTABLISHED WE CAN BUILD A MATRIX WHICH WILL SERVE AS THE INPUT FILE FOR THE SPREAD ROUTINE PROGRAM, THE ESSENCE OF THIS MATRIX WILL BE TO CONVEY TO THE PROGRAM THE FOLLOWING INFORMATION: PER CENT COMPLETE, ESTIMATE TO COMPLETE, CURVE MODEL SELECTION, KEY DATES, ALONG WITH THE AVAILABLE BUILDING POSITION FOR EACH HULL,

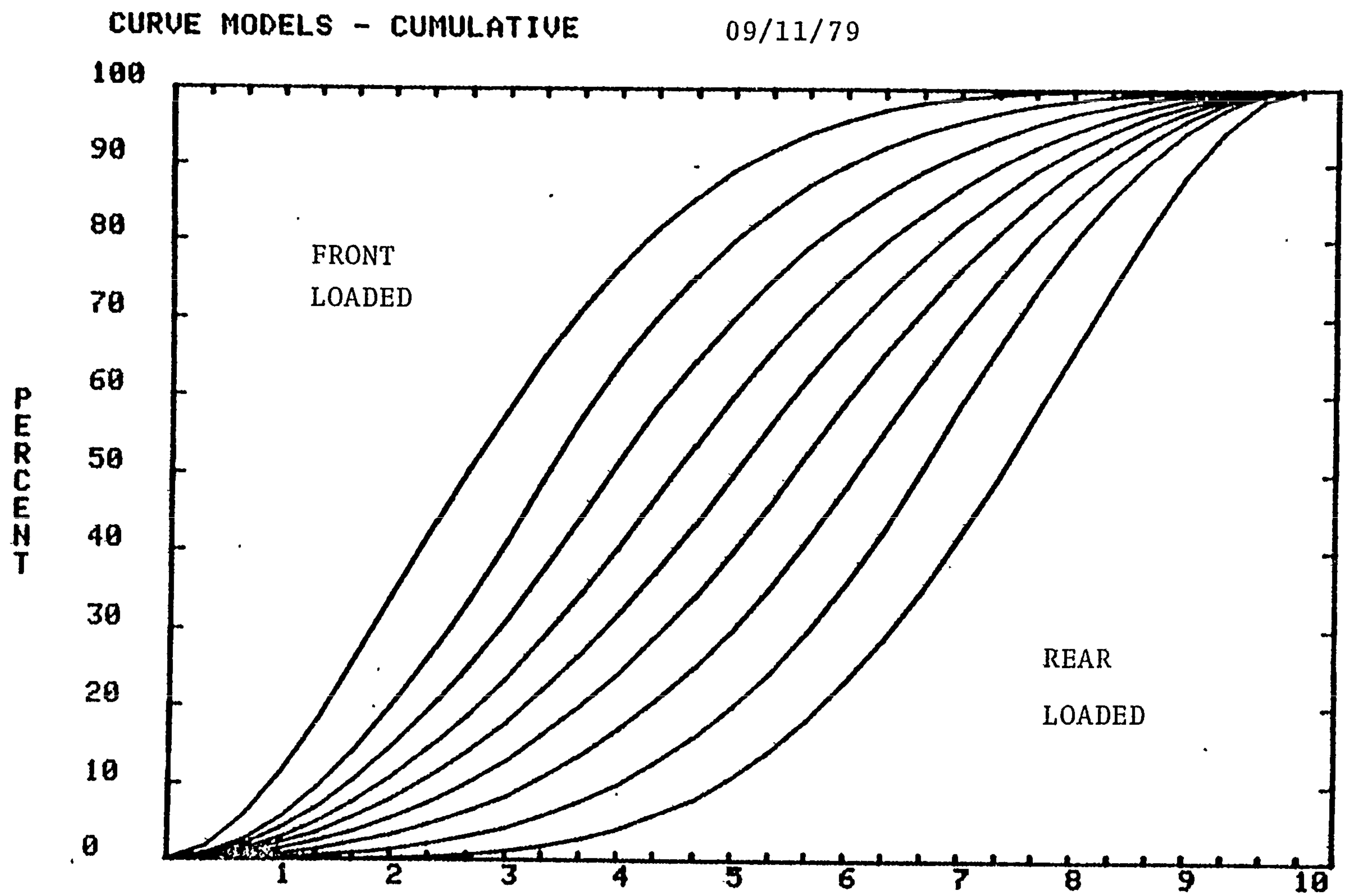

CURVE MODELS - CUMULATIVE
09/11/79
PERCENT
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
FRONT
LOADED
REAR
LOADED

Figure 2.

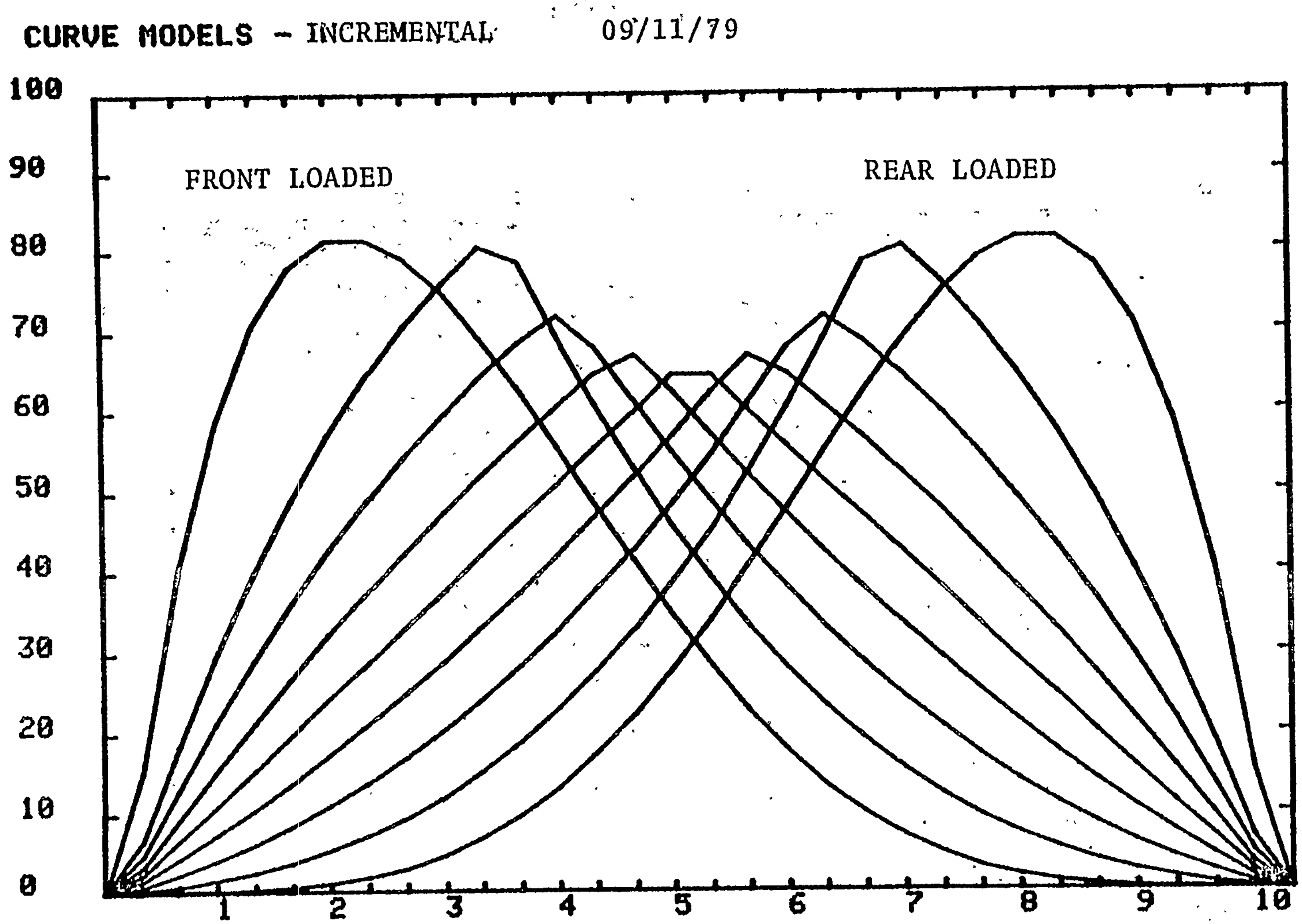

CURVE MODELS - INCREMENTAL 09/11/79
100
90
80
70
60
50
40
30
20
10
0
FRONT LOADED
REAR LOADED
1
2
3
4
5
6
7
8
9
10

Figure 3.

THE PROGRAM IS THEN EXECUTED YIELDING RESULTS DEPICTED IN FIGURES 4, 5, AND 6. FIGURE 4 IS THE SCHEDULE OF SHIP DELIVERIES WHICH DISPLAYS THE KEY DATES (I.E. START OF CONSTRUCTION, KEEL, LAUNCH AND DELIVERY) FOR PREVIOUSLY COMMITTED WORK AND THE ANTICIPATED NEW BUSINESS (I.E. ONE BARGE), FIGURE 5 DEPICTS HOW THE BUILDING WAYS WILL BE UTILIZED, FINALLY, THE MANPOWER REQUIREMENTS ASSOCIATED WITH FIGURE 4 ARE SHOWN ON FIGURE 6 FOR BOTH FIRM AND THE POTENTIAL NEW BUSINESS, MANPOWER DISPLAYS MAY ALSO BE PRODUCED FOR CRITICAL TRADES, WORK CENTERS, OR DEPARTMENTS,

IN SUMMARY, I WOULD LIKE TO RELATE TO YOU THAT WE AT NASSCO HAVE PRODUCED TIMELY AND COST EFFECTIVE INFORMATION FOR LONG RANGE PLANNING USING THIS TECHNIQUE, WE FEEL IT IS ESSENTIAL THAT OUR SHIPYARD, FINDING OURSELVES IN A DYNAMIC MARKET PLACE, BE ABLE TO MAKE RAPID, YET ACCURATE ASSESSMENT ON THE RESOURCES REQUIRED TO SUPPORT ANTICIPATED NEW BUSINESS (I.E. SOLICITED OR UNSOLICITED),

A B C SHIPBUILDING
AND DRYDOCK CO.

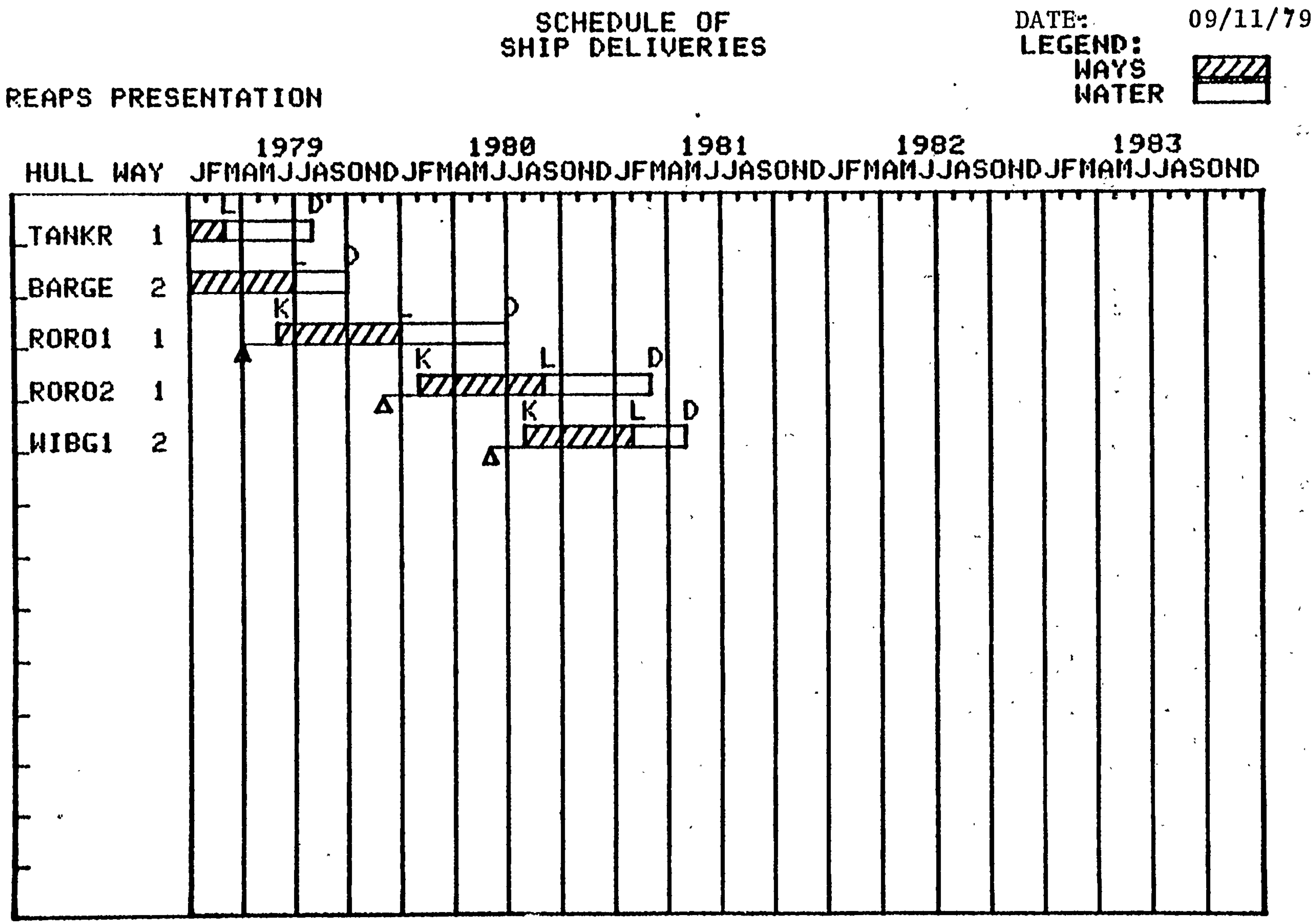


Figure 4.

A B C SHIPBUILDING

AND DRYDOCK CO.

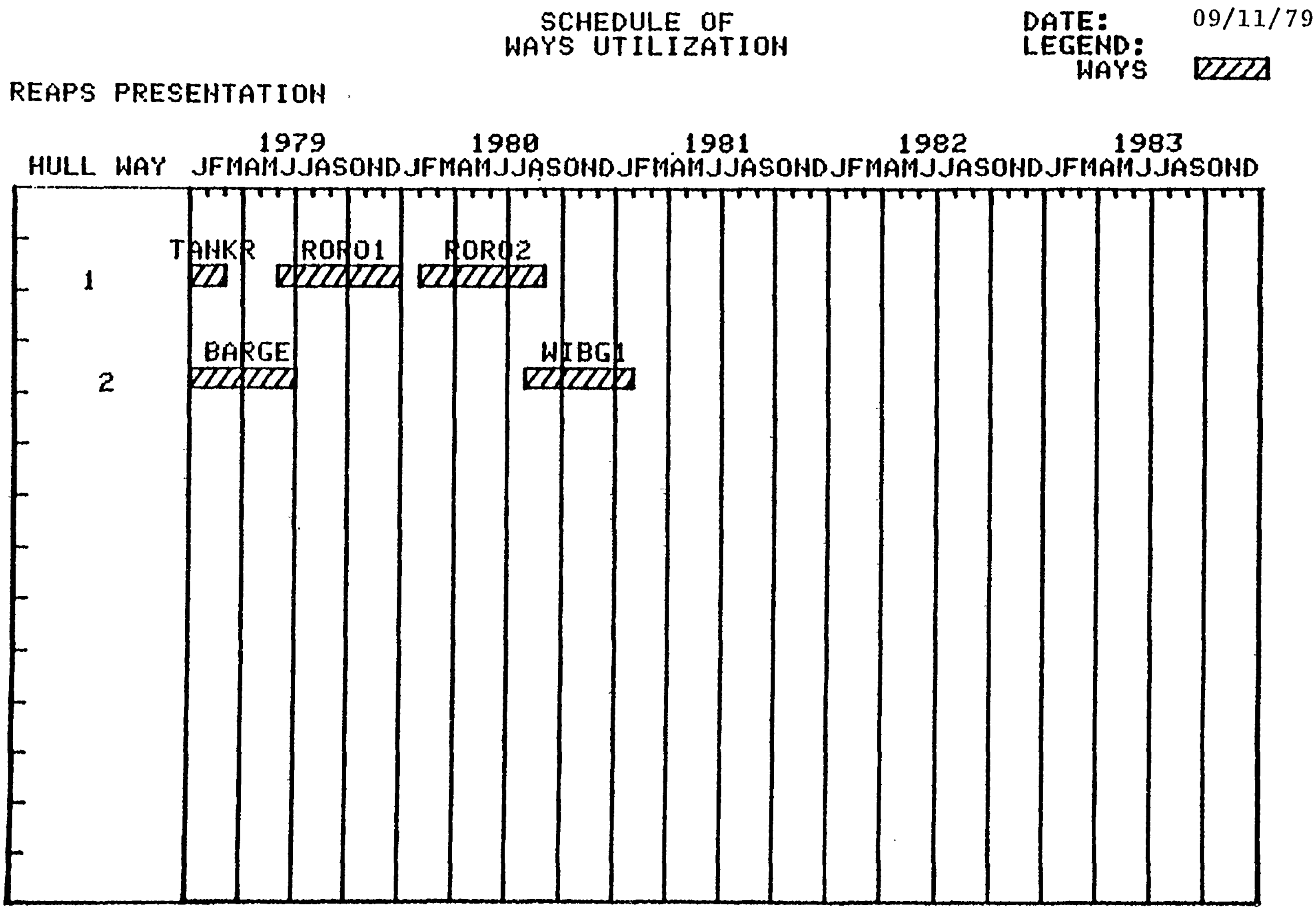


Figure 5.

A B C SHIPBUILDING
AND DRYDOCK CO.

REAPS PRESENTATION 09/11/79

MANLOAD

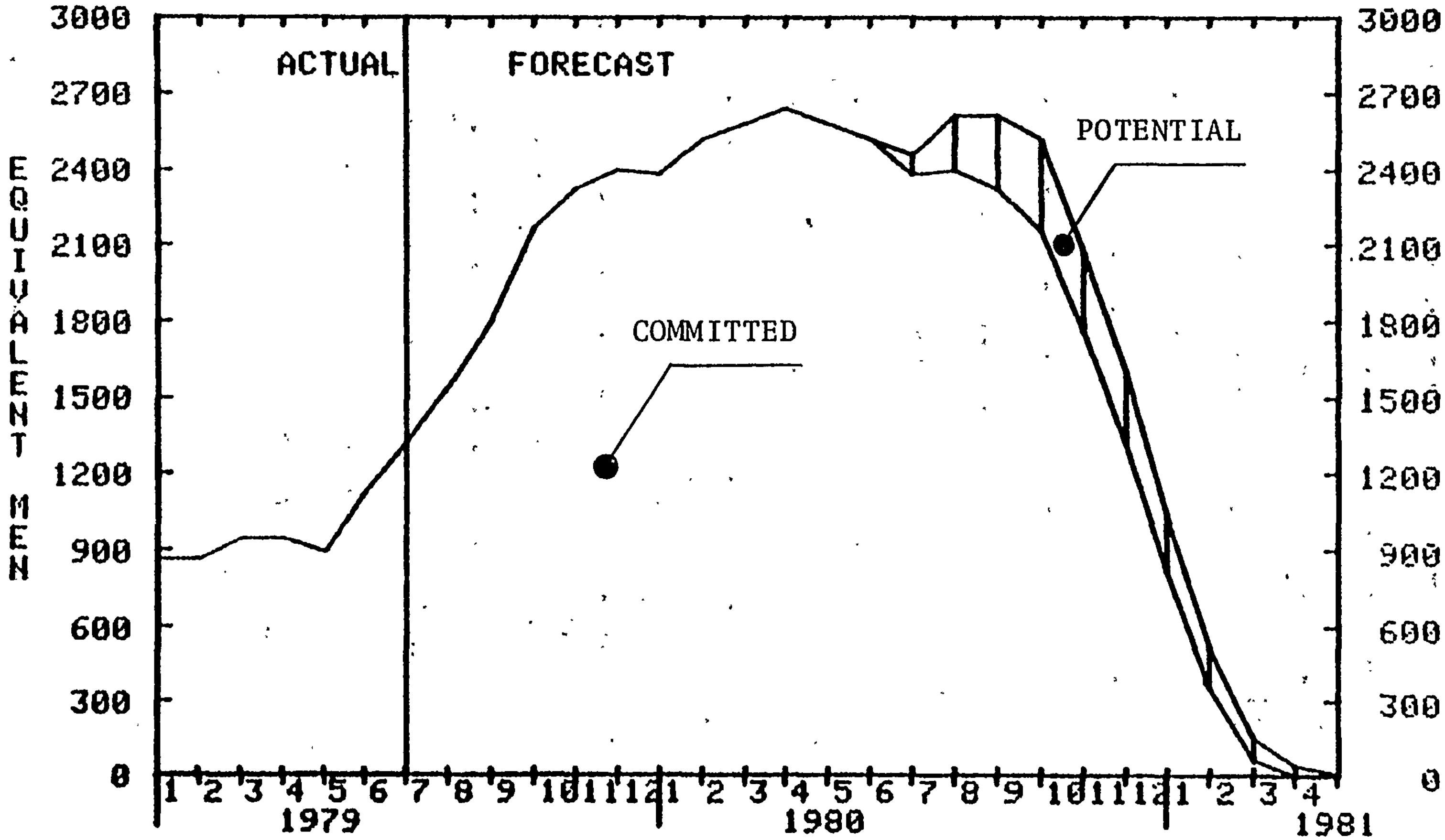


Figure 6.

SHIPBUILDING EVALUATION AND ANALYSIS SYSTEM

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Ms. Forman is currently responsible for conducting studies to evaluate the effectiveness of the Maritime Administration programs, and for analyzing program plans and proposals in conformance with established policies.

Ms. Forman holds degrees from the University of Maryland and Prince George's Community College. As a computer specialist for the Maritime Administration's engineering computer group, Ms. Forman was previously responsible for the analysis, design, installation, improvement and maintenance of the Office of Ship Construction's ADP systems. She has also held the positions of Engineering Aid for Biotechnology Inc, and Electrical Draftsman for a number of corporations.

John M. Hotaling
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As Manager of Shipbuilding Analysis, Mr. Hotaling currently manages projects that involve Government interest in ship construction scheduling, manpower requirements, production status, and outyear program planning.

Mr. Hotaling has a degree in marine engineering from the U.S. Merchant Marine Academy, and a masters degree in mechanical engineering from Rensselaer Polytechnic Institute. His previous positions include Staff Engineer in the Ship Production Office at Naval Sea Systems Command, and Project Manager/Engineer in the Division of Engineering at the Maritime Administration's Office of Ship Construction.

I. INTRODUCTION

The objective of this paper is to discuss the **elements of** the computer model , Shipbuilding Evaluation and Analysis System (SFAS) concerning: how SFAS is used in the maritime Administration (MarAd) **management decision making process**; the capabilities of the model; and the interactive relations between the model users and the shipyards.

SFAS is a group of computer modules designed to provide evaluations and analyses pertinent to all phases of the shipbuilding process. The modules provide various reports and graphical information. The graphical information is in the form of workforce curves and scheduling charts. The following are typcial SFAS applications : workload analyses of shipyards; assessment of building position. availability and facility utilization; mobilization *base* analyses ; depicting the requirements for critical materials in shiphuildinp ; determining shipyard capabilities ; **S-year shipbuilding forecast; budget** for U.S. ship construction program with and without CDS; determining labor and training requirements in shipbuilding; analyses of U.S. ship repair and reactivation capabilities; and carriage capacity for specified ship construction programs.

The elements of the SFAS were designed for **maximum** flexibility to be used by MarAd management in assessing certain situations and also in decision making on policy matters. An individual familiar with ship production terms and production scheduling can *use* most of the SFAS modules by reference to the users guide. Computer programming, or special skills in ADP technology are not required of the user. However, a certain amount of knowledge of terminal operations is a must.

The data base is updated continually with information received from shipyards. Therefore, reliable analyses cannot he accomplished unless there is full cooperation between MarAd and the shipyards. At this time MarAd is enjoying more than sufficient cooperation and this relationship has enabled the model to be very successful.

Questions regarding SFAS development, design, and use should be referred to Ms. Joan Forman, Division of Program Analysis, or MR. John Hotaling, Manager Shipbuilding Analysis, division of Production, Office of SHIP Construction.

The SFAS system has been expanding greatly in its present configuration and now has many more capabilities than its predecessor, the Shipyard Production End Mobilization Model (SPAMM).

II. HISTOPY

The Maritime Administration, in accordance with the declaration of policy stated in Title I of the Merchant Marine Act Of 1936 as amended, shall be responsible for fostering the development and maintenance of an American merchant marine sufficient to meet the needs of the national security and of the domestic and foreign commerce' of the United States. In carrying out these responsibilities, the Maritime Administration shall award and administer construction-differential subsidy (CDS) contracts to aid the American merchant marine and the nation's shipbuilding industry. In the execution of this function, the Office of Ship Construction has the responsibility. of developing and maintaining shipyard reporting and information systems; analyzing specific shipbuilding programs; the responsibility of developing methods for measuring shipyard capacity and capabilities; report findings; conclusions and recommendations.

To administer these contracts, as well as to assess the potential for new contracts, the Office of Ship Construction needs a continuous data flow. This data flow and the necessary subsequent analysis are provided for in part by the Shipbuilding Evaluation and Analysis System (SFAS).

In 1973, the Office of Ship Construction developed the Shipyard Production And Mobilization Model (SPAMM) as an efficient tool to display workforce distribution, construction schedules, and steel requirements on an individual yard basis. These capabilities were described in the paper entitled “Shipyard Production and Mobilization Model" presented in March 1974. SPAMM also was used at that time not analyze facility and workforce constraints of the shipbuilding industry under mobilization criteria assumptions. As

become the data backbone of the Shipbuilding Evaluation and Analysis System.

Development of the SFAS system: in its present form began its gestation period with the, installation of a Tektronix 4014-1 Graphic Display Unit in July of 1976. As interactive graphic software was investigated, debugged and implemented by the Engineering Computer Group, the strength and versatility of SPAMM Began to be realized.

Since 1976, the Engineering Computer Group and the Division of Production gained experience with computer graphics and have been able to incorporate many innovative features into the package of program modules to increase the capability and reliability of various routines.

During the second large joint Navy-MarAd mobilization study in 1977, SPAMM was enhanced. significantly in many areas and the present SEAS configuration was conceptualized by the authors.

It became necessary to separate the SPAMM new construction analysis functions from the mobilization study functions. Utility programs were developed to address problems such as interfacing with the Navy Coordinated Ship Data System (CSDS) model and handling large data base changes or producing special output such as steel demand curves. Utility programs developed for special cases became so important to the efficient operation that they are now considered a separate portion of SFAS. Office of Ship Construction management of merchant vessel construction under Title XI of the Merchant Marine Act required an information system that could serve a wide variety of report requirements. This section of the SFAS has been separated because portions of the data bank reside on our inhouse Honeywell computer and are not directly linked to the other portions of the modules without data transfer mechanisms between different computers. Data base concerns have not allowed full integration with the other three areas of SEAS.

III. PURPOSE OF ‘THE SFAC MODEL

The SFAS model provides a tool for shipyard workload analyses. Workload analyses can be performed by hand, but for MarAd management there frequently is a severe requirement for fast, and relatively accurate answers. If these two factors were the only criteria, speed is more important than accuracy. Accuracy, within the plus or minus range of 5%, would be considered extremely good for the SEAS model.

Workload analyses usually are either individual yard analyses or total. industry impact studies. An individual shipyard's production scheduling and workload must be considered before a CDS contract can be signed. When a ship owner needs to build a ship, and applies for CDS, the Office of Ship Construction receives and reviews the plans and specification. Part of this review also includes the certification that the shipyard or shipyards that are bidding the job can perform under the terms of the contract. This certification means, in the opinion of the Office of Ship Construction, a yard can perform the contract because they have the management, technical capability, facilities and workforce to handle the proposed work. The Division of Production is responsible for conducting the analysis which forms the basis of these certifications.

Summary analysis for assessment of the industrial impact of various proposed policy or legislative initiatives can be handled easily by SFAS and is useful and important to the industrial analyst.

Total industry impact on policy changes such as Department of Defense funding cutbacks or cargo preference legislation can be analyzed. The overall loss of shipyard workers because of a declining orderbook, or as we saw several years ago, the consideration of over capacity, are important trends that cannot he taken lightly. Specific examples of workload analyses for both an individual shipyard and industry impact will be explored later in the paper.

SFAS also provides the user with a tool and method for assessment of building position availability and facility utilization. 'A specific yard can be

examined in detail by building position scheduling, repair dry dock utilization or even pier space scheduling if required. From a macroscopic perspective, the total facilities avail ability and adequacy can be studied as it relates to "What if" assumptions about projected workload generated by market surveys, proposed legislation, or war game battle damage etc.

The facilities analyses are also divided into relatively the same two areas as the workforce analyses, that is, individual. yard analysis and total industry aggregates.

Peacetime programs such as the Navy and MarAd 5-year shipbuilding programs can increase or decrease drastically as different budget proposals increase or decrease. These "what if" variations are looked at throughout each year. Facilities utilization studies can be in the mobilization area where the requirement for an adequate fleet is specified and dictates a required shipbuilding mix and rate. Rattle damage has to be repaired and the total facilities requirement for the complete U.S. industry is then defined. The total facilities availability is handled by the SEAS model. Peacetime facilities availability studies are also conducted, along with these facilities analyses the inherent material analyses are possible. SPAS has the capability to depict the requirement for critical materials in shipbuilding. Steel demand curves are the only material information presently being used. However, other critical raw materials can be substituted. The shape of the distribution curves can be easily adjusted to enable SFAS to portray demand for many of the critical shipbuilding materials. Again these fall in both mobilization and peacetime analysis categories. Shipbuilding program mixes are analyzed in all of these areas. The interaction is examined between large Nava1 shipbuilding programs, commercial shipbuilding forecasts, drill rig

construction, supply boat activity, along with additional non-ship work. Sensitivity of the industry to MarAd subsidy funding level changes is investigated from time to time for various reasons. The SFAS model is used to tie together the interactions of these "What if” scenarios for overall impact on the U.S. shipbuilding industry.

SFAS interacts within many areas of the Maritime Administration. In the MarAd planning process, the Office of Policy and Plans will frequently conduct a market survey of potential ship construction projects from ship operators and owners. With this market survey and knowledge drawn from the financial aid replacement obligations of the various ship operators, the Office of Policy and Plans generates a 5-year shipbuilding forecast. This forecast has two parts: the ships that are scheduled to have construction-differential subsidy, and those projected that probably will be built without construction-differential subsidy. This 5-year plan is then compared and integrated with the current Navy five year shipbuilding program. The Navy five year shipbuilding program runs in many cycles during the calendar year, depending on the budget cycle or Congressional authorization. A current 5-year plan is shown as Appendix A of this paper. The projected shipbuilding programs have become smaller over the last 2 or 3 years reflecting the worldwide shipping and shipbuilding slump and the concurrent lower demend for ships.

Five year workforce and facility utilization forecasts can he used for: generating the CDS budget ; reviewing the CDS requirements and funding allotments by program planning and budget personnel in MarAd; training and labor requirements can be reviewed by the Office of Labor and Training in MarAd;

and forecasting early warning signals for shipyards in trouble, when they need new contracts, and when workforce level demands go above or below reasonable limits for efficient operation.

IV. RFPORTS

Accurate and timely status reports are another important function of the SFAS system. MarAd management requires large amounts of statistical data in the execution of daily business. The monthly shipbuilding progress report is the most popular and most widely used report generated by SFAS.

The report provides all of the top line ship production progress and scheduling information to Marad management in a concise format. All the data available to the division of Production for all major commercial oceangoing and Great Lakes ships under construction in the U.S. is updated continuously in the SFAS data hank. The report is divided into two portions. Tabulated initially are all ships with construction-differential subsidy. The second section is privately financed construction that does not have CDS. The monthlv progress report gives the following data on al! commercial vessels larger than 1000 gross tons under construction in U.S. shipyards:

Yard	Vessel Name
Design	Vessel Owner
Vessel Type	Percent Complete
Deadweight	Contract Award Date
MA Hull	Start Fabrication Date
Builder Hull	Keel Date
Type of Financial Aid	Launch Date
Contract Number	Contract Delivery Date
	Estimated Delivery Date

Copies of this report have been made available separately. Monthly issues are available through the division of Production. Contact Mr. James Bowman, phone 202-377- 2803.

The second most widely distributed report is our TITLE XI (Ship Financing Guarantees) report series. This report has three portions printed separately. Data for this report is acquired from a master Title XI computer file that supports all three separate reports described below. Data collection commences when application for Title XI financing is received by MarAd. The three sections are:

Title XI Project Status Report

The Project Status Report is a quarterly publication reporting project status information of the Title XI applications from January 1977 to present time. Specifically the information displayed in a tabular form for each application is as follows:

Title XI Application Number	Contract Delivery Date
Owner Name	Estimated Delivery Date
Ship Type	Trial or Inspection Date
Vessel Name	Percent Complete as of a Designated Date
Shipyard Built	Status of Title XI Application
Construction Representative Assigned	Type of Title XI Application
Award Date of Construction Contract	Status of Title V Application

This report is intended for Construction Representatives, supervisors, and other personnel that are directly involved in Title XI application approval and vessel construction. Other organizations may also desire the information concerning the project status of Title XI applications.

Title XI Principal Characteristics Report

The Principal Characteristics Report is a quarterly publication reporting hull characteristics information of the Title XI applications from January 1977 to present time. Specifically the information displayed is as follows:

Title Xi Application Number	Beam
Owner Name	Depth
Ship Type	Draft
Vessel Name	Deadweight (DWT)
Shipyard Built	Displacement and Lightship Gross Tonnage

Construction Representative Assigned	Shaft Horsepower (SHP)
Builder and MarAd Hull Number	Vertical Center of Gravity (KG)
Length Overall (LOA)	Machinery, Steel and Outfit Tonnage

This report is intended for use mainly by the Division of Naval Architecture hut many other organizations desiring information on the principal characteristics of Title XI vessels have found it to be very useful.

Title XI Financial Status Report

The Financial Status Report is also a quarterly publication reporting financial status information of the Title XI applications from January 1973 to present time. Specifically, the information displayed is as follows:

Title XI Application Number	Balance Cost Remaining
Owner Name	Contract Number
Ship Type	Contract Delivery Date
Vessel Name	Contract Award
Shipyard Built	Status of Title XI Application
Contract Cost	Type of Title XI Application
Original Mortgage Cost	Status of Title V Application

This report is intended for use mainly by the Office of Ship Financing Guarantees.

In addition to the shipbuilding progress report and the Title XI reports, the Division of Production generates a quarterly shipbuilding status report. This differs significantly from the other shipbuilding reports in that all of the work in each yard is represented, including Naval construction, repair and non-ship work. Information is graphically shown by bar chart schedules for each building position and workload curves yard by yard.

A workload and schedule analysis of all of the shipyards in the active U.S. shipbuilding base is presented in this report each quarter. At present there are 24 yards that are considered to be in the active shipbuilding base. These are the yards that are building or seeking contracts for construction of major oceangoing or Great Lakes vessels 1,000 gross tons or larger.

Recognizing that this is an arbitrary definition, many other yards are included in this quarterly report which may be of interest to some of the users. However, only the active shipbuilders are used in the total industry summation workload curve. The model has the ability to run summations on as many combinations of yards and curves as the user desires. Similar tailor made reports are often generated on a special case basis.

The quarterly shipbuilding status report has a summation of the industry workload showing the workforce requirements to complete all the work under contract in the current orderbook backlog. After the industry summation, each yard is presented alphabetically. First a bar chart schedule of all firm work is presented for each building position in the yard showing the currently scheduled key event dates. On the next page a workload curve is depicted showing workforce requirements and trends within the yard to complete the firm work. This information gives early warning to yards in trouble due to lack of work, or overloaded situations. The relationships between workforce projections and building position schedules are good indicators for the analyst to use in drawing conclusions concerning MarAd programs.

Up until late 1978 this report was widely distributed and enjoyed a mailing list of about 200. However, one shipyard currently considers its building position schedules as proprietary in nature and several shipyards now consider their manpower information as proprietary. In order to respect these positions the Division of Production now has made this report FOR OFFICIAL USE ONLY, FOUO. and restricts distribution to governmental users only. The only schedule information not publicly distributed in the monthly progress

reports are the actual building position assignments. For the purpose of exemplifying the SEAS capability, an abbreviated issue of our quarterly report is given in Appendix A, This is an example of what the individual shipyards contribution resembles and the current summary active shipbuilding base workload curve. Also included is a sample data form MA 832 not normally printed with the report.

V. NEW' DATA SOURCES

SFAS is no different than any other computer model, in that, the most important element is the input data. The validity and reliability of the data is extremely dependent upon two key factors: (l) The data base must be current and continually updated; (2) The data must be valid, Therefore, it is of the utmost importance that the shipyards report valid, timely information when required. Also, it is essential for the industrial analyst in charge of the model to have continuous knowledge of the yard programs and capabilities. By frequently visiting the yards in the active shipbuilding base, the analyst can keep abreast of recent shipyard improvements.

The old SPAMM model had a small, but annoying defect in that it built up the workforce demand curves by addition of standard workforce distributions ship by ship. By using standard distributions a very close correlation to actual workforce distribution is given if each of the ships is on schedule and not impacted by other work so that it follows the "normal" curve. Because this rarely happens, these curves were being adjusted frequently to match known delays. The credibility of workforce information was in question because it was always slightly different from a particular yard's curve or NAVSEA information. Although each of the differences could he explained on

a case-by-case, basis, the fact that frequently the yard, MarAd, and the Navy would have three different depictions of the same production workload and schedule became troublesome to management particularity during Congressional testimony. This capability has been retained to be used when actual data may not be available.

During 1977 the issue of what is the nation's "shipbuilding capacity" was a matter of public and industry concern. Navy, MarAd, and Shipbuilders Council of America (SCA) had three separate and distinct appraisals of the industry's ability to produce ships. This highlighted the need to define more accurately the "active. U.S. Shipbuilding Industrial Base. " SCA surveyed all shipbuilders, both members and non-members. Due to the efforts of Mr. Stuart Adamson of the Shipbuilders Council, the definition and common reporting of actual data from the active U.S. shipbuilding industrial base was initiated and is now used extensively.

A new data form incorporating all of the needed information was generated. This was' approved by the Office of Management and Budget in December of 1978, and was given the title Shipbuilding Orderbook and Shipyard Employment, and numbered MA 832. This form, combined with the facility information contained on the standard form 17, titled, Facilities Available for the Construction and Repair, of Ships, provides a relatively accurate depiction of each yard's status.

On August 21 of 1978, the Assistant Secretary of Commerce for Maritime Affairs requested each shipyard in the United States to participate voluntarily in the common reporting of ship construction, production, and workforce information. This would necessitate ail yards to submit a MA 832 form quarterly.

The Office of Ship Construction, Division of Production has developed and maintains the current data hank of all U.S. shipyards actively participating in or seeking construction of major oceangoing and Great Lakes ships 1,000 gross tons or larger. These yards by definition are the active U.S. Shipbuilding Base. This cooperation of the shipbuilders and the Government provides continuing and accurate data on the staffing requirements and facility availability of the shipbuilding base which is useful in many areas and benefits all participants.

VI. DATA BANK STRUCTURE

Six major data banks are used in the Shipbuilding Evaluation and Analysis System. ‘Ihis section will describe the contents of each data bank.

A. SPAMM - Shipbuilding Production and Mobilization Model Data Bank

For each shipyard in the data bank, the following characteristics are given:

1. Name of Shipyard
2. Number of building positions, drydocks, pier spaces, etc.
3. Length and width of each building position when applicable.
4. Vessels presently under construction and their characteristics.
   - a. Building position on which the vessel is being built.
   - b. Six key event dates:
     1. Contract award
     2. Start of fabrication
     3. Keel
     4. Launch
     5. Contract delivery
     6. Revised delivery

c. Design number

d. Maritime Administration Hull Number

e. Percent of completion

f. Work days to build vessel

g. Code for operator (Navy, Private, CDS)

h. Steel tonnage

1. Name of vessel

j. Vessel owner

k. Builder’s hull number

1. LEGEND - used in Monthly Progress Report

m. Mar-Ad's contract number

n. Vessel type

o. Deadweight

p. Percent gain - monthly

B. <u>MOB - Mobilization Data Bank</u>

For each shipyard in the data bank, the following characteristics are given:

1. Name of Shipyard

2. Number of building positions, drydocks, pier spaces, etc.

3. Length and width of each building position when applicable.

4. Vessels in the study and their characteristics.

   a. Building position on which the vessel is being constructed, or repaired.

   b. Five key event dates.

      1. Contract award

      2. Start of fabrication

      3. Keel

4. Launch

5. Delivery

c. Code for specified vessel type

d. Vessel type

e. Work days to repair or build vessel

f. Code for categorization of vessel manpower

g. Code for operator (Navy, Private, CDS)

g. Amount of steel' to repair or build vessel

C. TITLE XI DATA BANK

For each vessel in the data bank, the following characteristics are given:

1. Title XI application number
2. Vessel design type
3. Vessel owner
4. Vessel type
5. Number of ships for the specified vessel type
6. Vessel name
7. Contract number
8. Trial/Inspection date
9. Percent of completion
10. Percent of completion date
11. Contract award date
12. Contract delivery date
13. Estimated delivery date
14. Actual construction cost
15. Original principal cost
16. Balance cost

17. Government aid - type of Title XI insurance loan
18. Title XI status (pending, approved, withdrawn)
19. Overall length of ship (L.O.A.)
20. Beam
21. Depth
22. Draft
23. Deadweight
24. Steel Tonnage
25. Machinery (tonnage)
26. Outfit (tonnage)
27. Lightship (tonnage)
28. MarAd's hull number
29. Builder's hull number
30. Shaft horsepower
31. KG stability factor
32. Displacement
33. Start of fabrication date
34. Keel date
35. Launch date
36. Revised contract date
37. Work days to build vessel
38. MarAd's design number
39. Percent gain - monthly
40. Name of Shipyard
41. Code for MarAd's construction representative

D. NDRF - National Defense Reserve Fleet

For, each shipyard in the data bank, the following characteristics are given:

1. Name of shipyard
2. Number of building positions, drydocks, pier spaces, etc.
3. Length and width of each building position when applicable.
4. Vessels in the National Defense Reserve Fleet.
   a. Building position on which the vessel is being repaired
   b. Vessel type
   c. Number of days after M-day required to arrive at shipyard
   d. Number of days after M-day to enter building position
5. Number of days after M-day to exit building position
6. Number of days after M-day required to depart from shipyard.
7. Vessel name
8. Code for categorization of vessel manpower
9. Length of vessel
10. Width of vessel
11. Work days to build vessel
12. Code for operator (NDR, NAV, CDS)

E. User's Data Banks -(Ship Mixes)

For each vessel the following characteristics are given:

1. Building position on which the vessel is being repaired
2. Contract award date
3. Start of fabrication date
4. Keel date'
5. Launch date
6. Delivery date

7. Rescheduled delivery date

8. Vessel type

9. Work days to build vessel

10. Code for Operator (CDS, NAV, PVT)

11. Steel Tonnage

F. <u>IDB - Industrial Data Bank</u>

The contents in the IDB data bank are obtained from the Maritime Administration's form "Shipbuilding Orderbook and Shipyard Employment" (MA-832). The form is completed by shipyard personnel on a quarterly basis.

For each shipyard the following characteristics are given:

1. Name of shipyard
2. Workforce conversion factor for equivalents to actuals
3. Code for type of workforce
4. Quarterly production workers for eight categories
   a. Ship Construction
      1. MarAd
      2. Navy
      3. Other Federal
      4. Private
   b. Ship Repair
      1. Navy
      2. Other Federal
      3. Private
   c. Non-ship

VII. DISTRIBUTION CURVES

There are several distribution curves used in SEAS. Labor has three different curves : one for activation of NDRF ships, one for mobilization and one for peacetime. The mobilization distribution curve considers three shifts and the percentage of productivity for each shift. As would be expected, the NDRF curve is completely different than a mobilization or peacetime labor curve because the ship will be reactivated rather than constructed.

Only two distribution curves will be discussed; labor (peacetime) and steel.

A. LABOR DISTRIBUTION CURVE

After a shipyard has received a contract award, it must prepare a study of the rate at which labor is to be expended. This study results in a labor load “S” curve, typical of all erection curves, but allows for local variations and influences (Figure VIIa). Examples are: work stoppage from a strike, contract problems, bad weather, poor planning. Vertical coordinates are graduated in percent of total productive labor to be expended by the shipyard on the vessel. The horizontal measurement for the curve is recorded as a percentage of total actual construction time for the vessel. This actual time of construction may be defined as the quasi-building period representing the start of fabrication to vessel completion. In an effort to arrive at a “universal” labor curve, an empirical study of the labor levels of five shipyards throughout the United States was made. The data was entered into a least-squares program on the computer, which developed the composite third-order polynomial curve A, in Figure VIIb. This may be compared to B, which has been used by MarAd, and coincides with the curve used by the Navy. In the beginning, Curve A shows a higher percentage

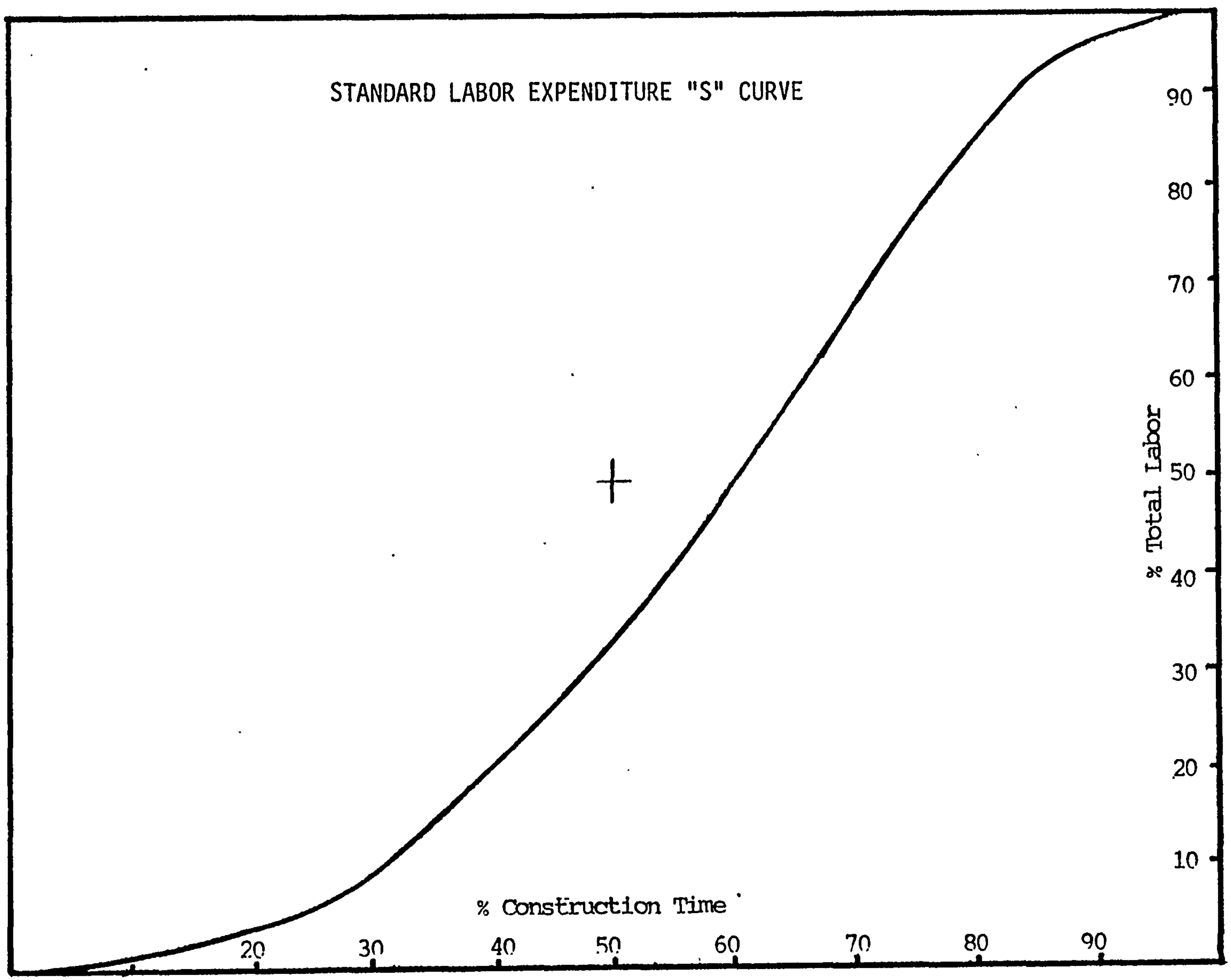

STANDARD LABOR EXPENDITURE "S" CURVE
% Total Labor
90
80
70
60
50
40
30
20
10
% Construction Time
20
30
40
50
60
70
80
90

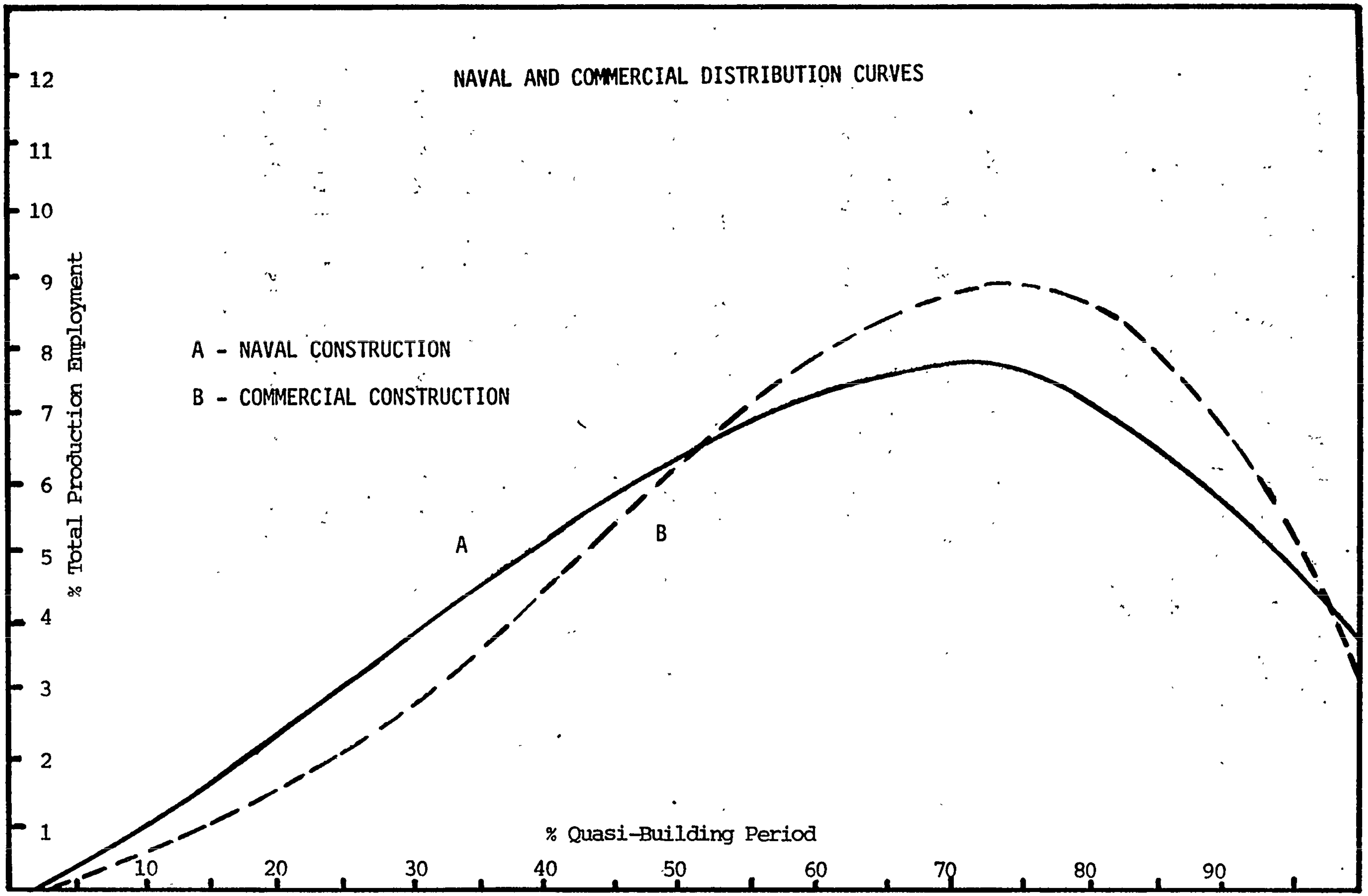
Figure VIIa

of labor than B, with a slower finish. The greater outfitting requirement of Naval vessels over commercial vessels may explain the discrepancy. It should be noted, however, that at the mid-point in time both curves have the same amount of employment Both curves, in addition, have their highest employment level around launching or between 70-75 percent of vessel completion.

The curves were developed under the concept that the various graduations of length of building period will always have the same corresponding percent of total production labor utilization. Thus, although ships will have different building period lengths-and total labor levels, their production labor distributions will be comparable.

The labor curve is critical in the functioning of the Shipyard Evaluation and Analysis System, as placement of proposed construction will be dependent not only on shipway availability, but on the distribution of labor. It is of utmost importance to maintaina minimum production labor force to ensure timely response to any ship construction demand. Figure VIIc shows the curve used in the Model. It is a synthesis of the Navy curve and MarAd's empirical curve which reflects a more stable level of employment than the Navy curve.

In addition, it allows a higher and longer peak employment level than the original MarAd curve. It is felt that both of these traits will allow the curve to closely reflect the actual employment characteristics of the various yards.



NAVAL AND COMMERCIAL DISTRIBUTION CURVES
A - NAVAL CONSTRUCTION
B - COMMERCIAL CONSTRUCTION
A
B
% Total Production Employment
12
11
10
9
8
7
6
5
4
3
2
1
% Quasi-Building Period
10
20
30
40
50
60
70
80
90

Figure VIIb

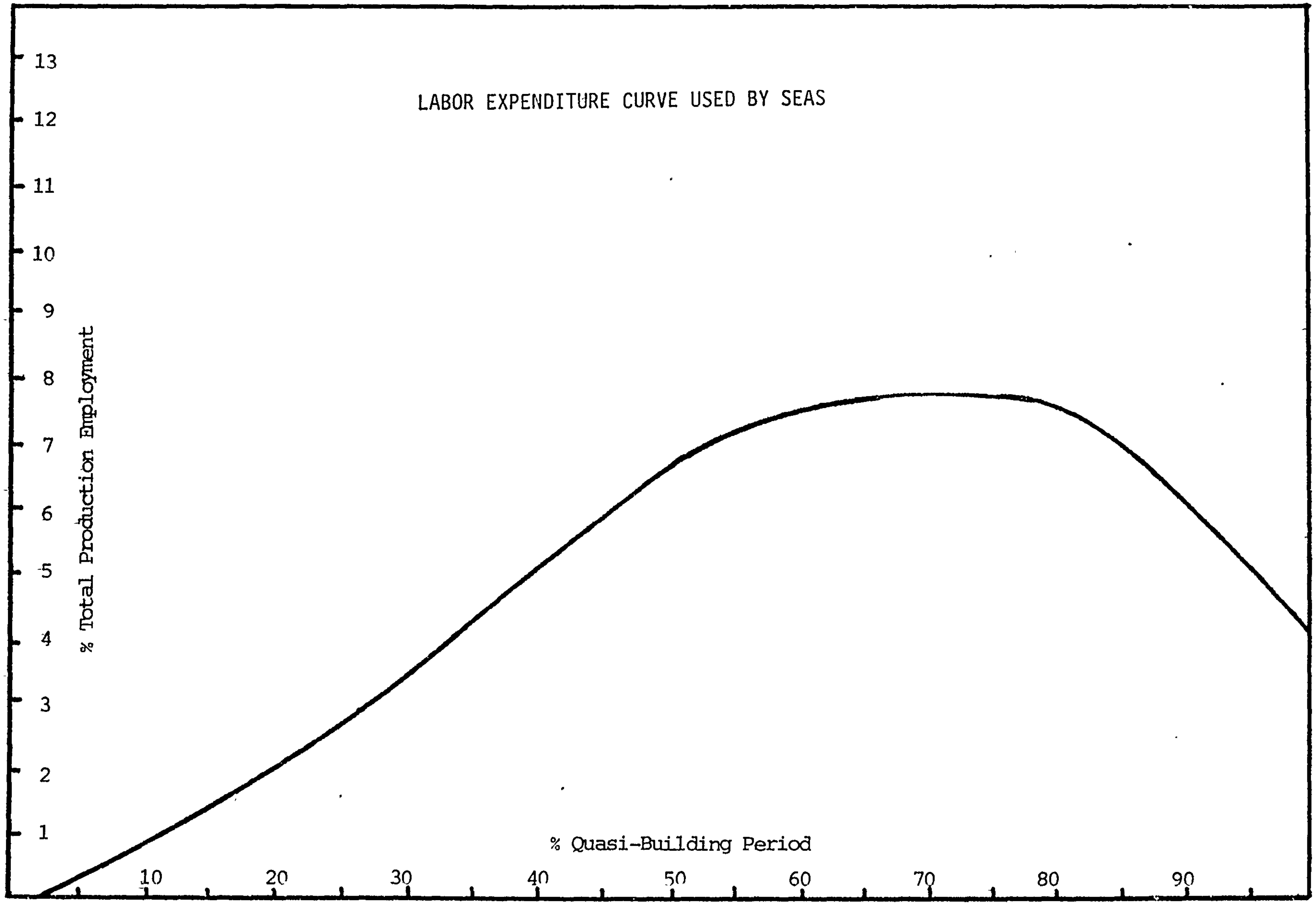

LABOR EXPENDITURE CURVE USED BY SEAS
% Total Production Employment
% Quasi-Building Period
13
12
11
10
9
8
7
6
5
4
3
2
1
10
20
30
40
50
60
70
80
90

Figure VIIc

B. STEEL DISTRIBUTION CURVE

A steel distribution curve has been developed along similar lines as the labor distribution curve. However, the steel steel curve is almost the reverse of the labor curve (see Figure VIId). As .one would expect, the largest amount of steel is required during the early stage of construction.

The vertical coordinates are graduated in percent of total tonnage (short) to be expended by the shipyard, on the vessel. The horizontal measurement for the curve is recorded as a percentage of total actual construction time for the vessel. The actual time of construction may be defined as the quasi-building period ranging from 3 months prior to the start of fabrication to one month after the vessel has been launched. This is a demand curve for steel ordering, assuming 3 month delivery of steel to the yard.

VIII. SOFTWARE MODULES

The Shipbuilding Evaluation Analysis System (SEAS) consists of 31 program modules, 25 Fortran and 6 Management Data Query (MDQ) modules.

The Fortranmodules are grouped according to their primary functions. The three groups are: (1) Shipbuilding Production and Mobilization Model, (2) Mobilization Studies, (3) Utility Routines.

The MDQ modules are used to provide the Title XI applications and Ship Characteristics Reports.

The capabilities and functions of the modules and data banks are discussed in the following paragraphs.

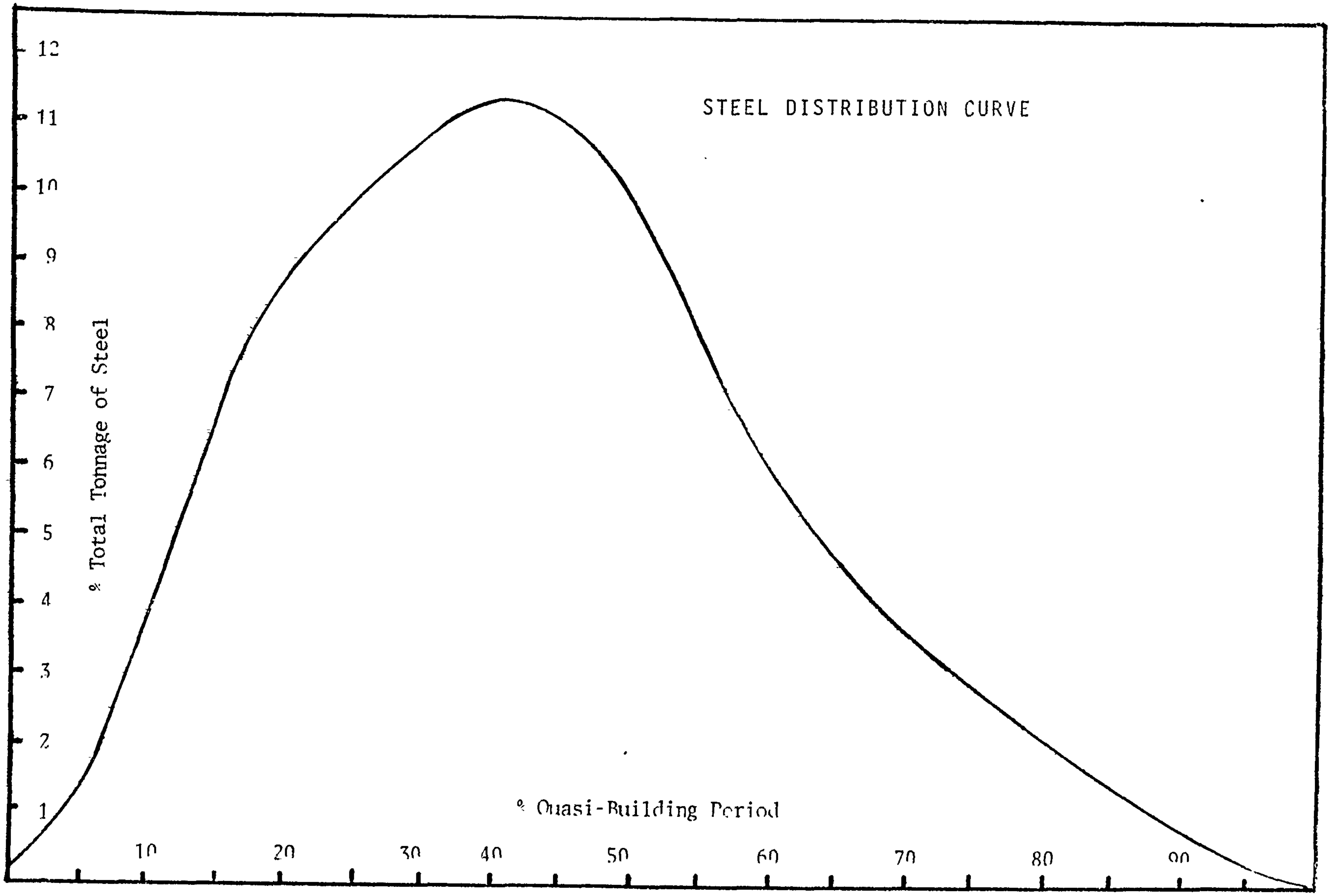

STEEL DISTRIBUTION CURVE
% Total Tonnage of Steel
12
11
10
9
8
7
6
5
4
3
2
1
% Quasi-Building Period
10
20
30
40
50
60
70
80
90

Figure VIId

A. SPAMM - Shipbuilding Production and Mobilization Model

SPAMM has the greatest utilization of the three groups. It provides analyses and management information pertinent to all phases of the shipbuilding process. Examples of pertinent information are: evaluating the feasibility of proposed shipbuilding programs ; identifying the need for construction of new facilities to meet the demands of proposed shipbuilding programs; responding to queries received from a variety of interests, including members of Congress, the Secretary of Commerce, the Department of Defense, and the office of Management and Budget; determining which existing shipyards might construct proposed ships consistent with ship size and delivery date requirements.

The SPAM data bank is continually updated, and the program modules are accessed daily. The data bank is comprised of more information per ship than other. *data* banks in SEAS, because of variable information required on a daily basis.. Since the data bank has high activity, it is required to be continually accessible.

The program modules are also required to be continually accessible. All modules are interactive, therefore enabling the requested information to be readily available. The information is produced immediately, in a report or graphic format on 8½"X11" paper .

Examples of the program modules capabilities follow:

PBARS - A module designed to provide workload schedule in a bar graph format for a specified ship mix.

The graphic schedule. consists of one bar graph per ship. Each bar graph is determined by six key event dates required in building a ship. The six

dates are: (1) contract award, (2) *start of* fabrication, (3) keel, (4) launch, (5) delivery, and (6) rescheduled delivery. This graphic schedule is extrememly beneficial in that the user can rapidly analyze the ship mix on an individual shipyard basis, and can determine if the ship mix is feasible. The graphic schedule is used for the "Status of Major Shipbuilding in U.S. Commercial Shipyards," quarterly report. See Figure VIIIa.

PCURVES - A module designed to provide a graphic manpower workload distribution curve for ship construction and repair. This enables- managerial personnel to analyze and produce rapid decisionmaking and policy determinat ions. For example, a proposed ship mix workload can be added to the existing manpower to determine if it is feasible for the shipyard to build the proposed ships. See Figure VIIIb.

PLEVEL - A module designed to provide either a graphic manpower workload distribution curve or a report format for ship construction utilizing six categories: Navy, Private and Coast Guard, Construction-Differential Subsidy (CDS), proposed Navy, proposed Private and Coast Guard, and proposed CDS. See Figures VIIIc and VIIId.

PSELBO - A module designed to select shipyards from the SEAS data bank in order to perform workload analyses on shipyards,

PROGRESS - A module designed to provide the monthly "Shipbuilding Progress Report."

PSELIDB - A module designed to select data from the Industrial Data Base.

PSILPRO - A module designed to select data from the Shipbuilding Evaluation Analysis System (SEAS) data bank, for the "Shipbuilding Progress Report ."

PSHIPS - A module designed to give the user a method to create data files [new construction - ships) for a specified ship mix expeditiously with a minimal amount of input.

BUILDING POSITION UTILIZATION

HOMAN SHIPBUILDING CO.

JUNE 11,1979

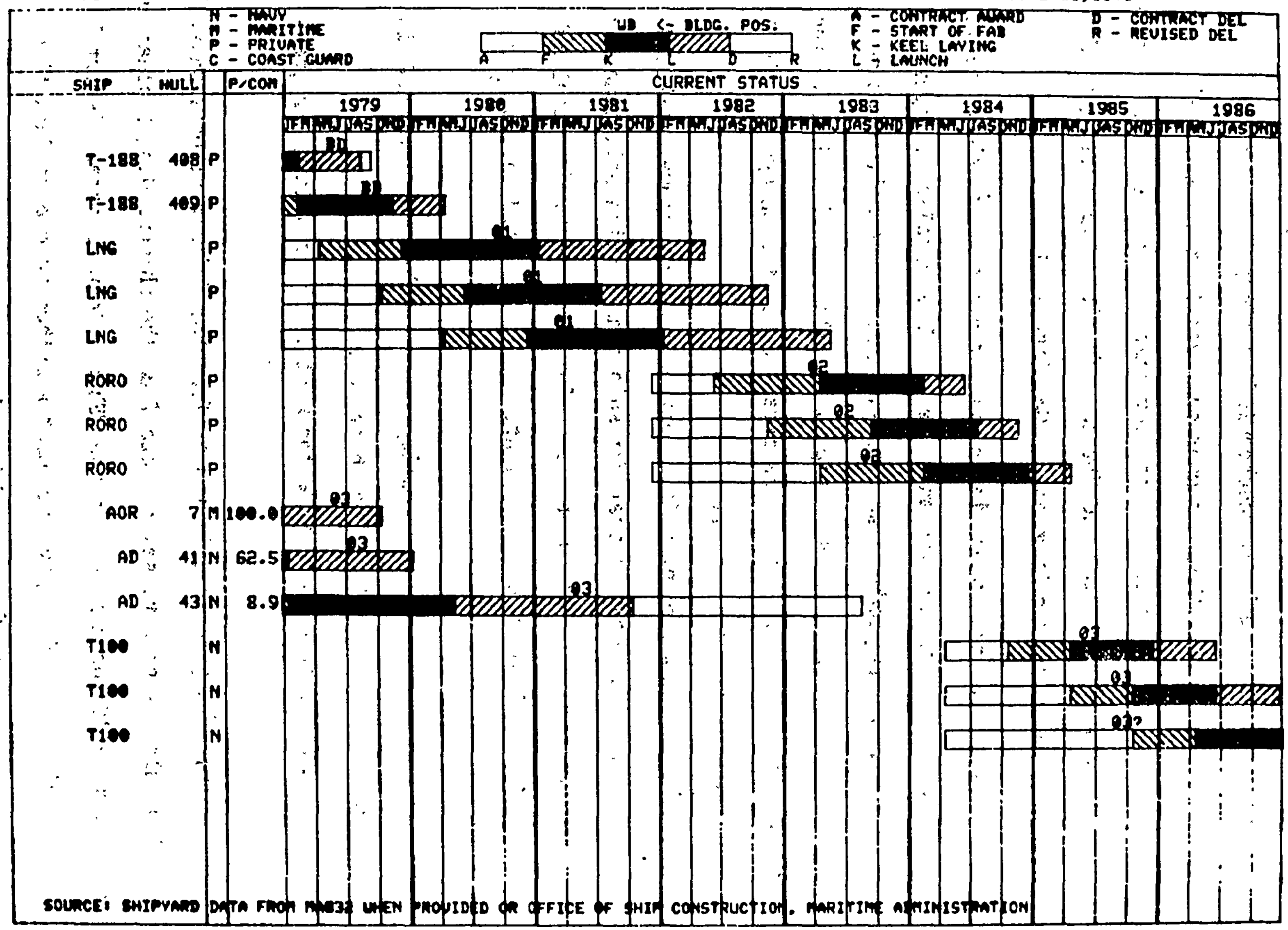
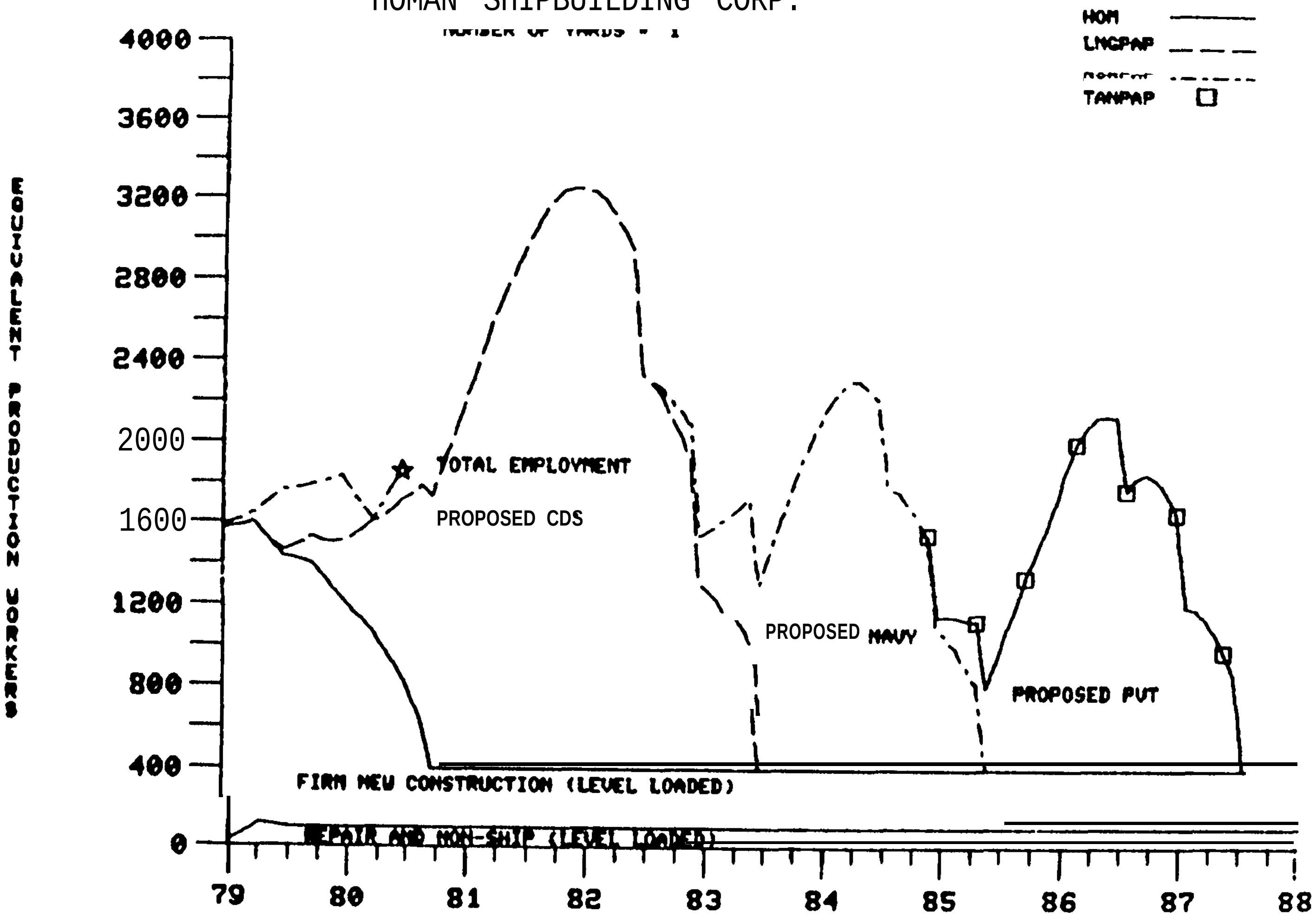


Figure VIIIa

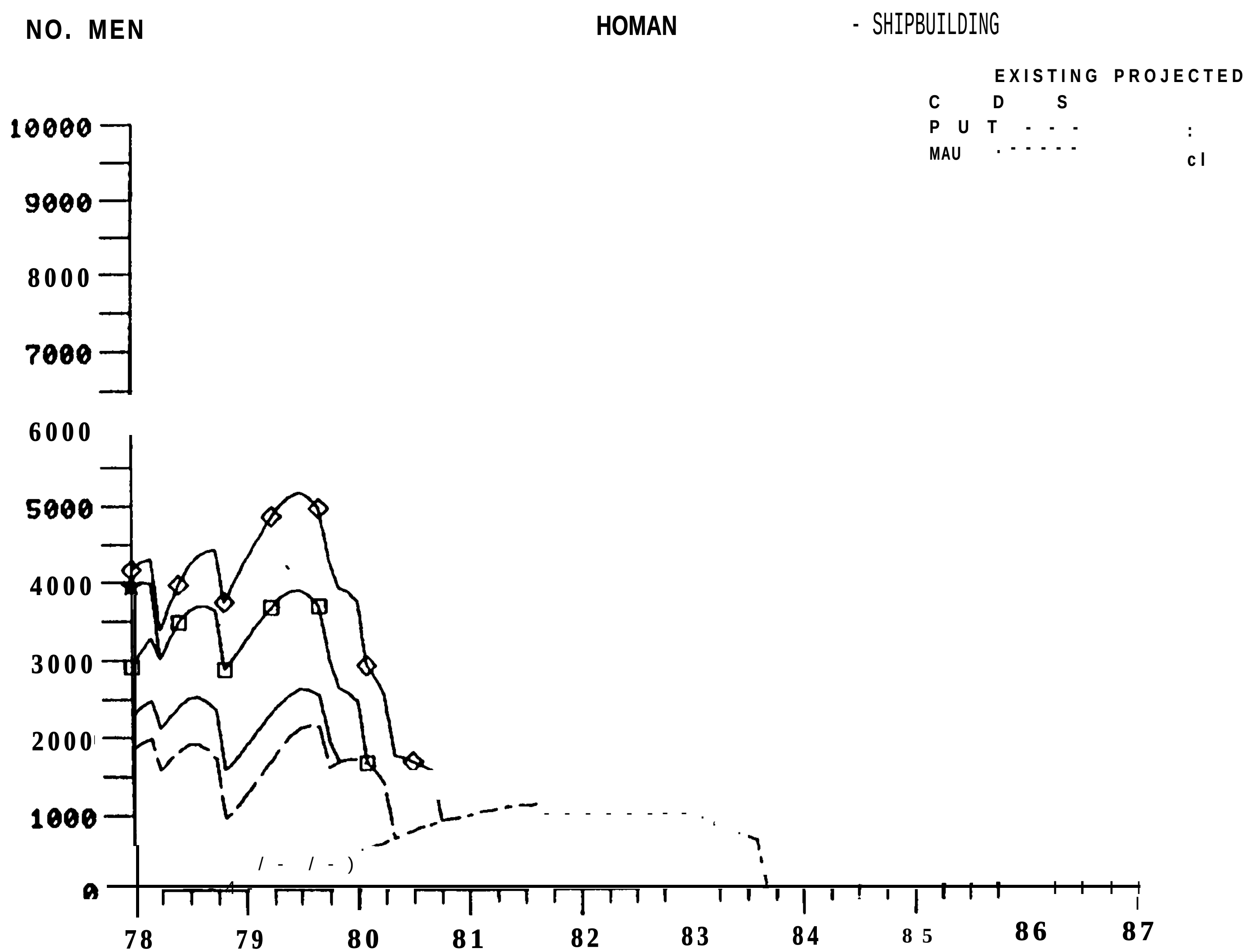
SHIPBUILDING INDUSTRY WORKLOAD PROJECTION

HOMAN SHIPBUILDING CORP.



MAY 9,1979

SOURCE: SHIPYARD DATA FROM FORM MA832 WHEN PROVIDED
OFFICE OF SHIP CONSTRUCTION, MARITIME ADMINISTRATION



APRIL 30, 1979

MANNING CURUE
OFFICE OF SHIP CONSTRUCTION

Figure VIIIc

SHIPBUILDING MANPOWER REQUIREMENTS
****

APRIL 30, 1979

SHIPYARD		DATE	NAV	PVT	CDS	P/NAV	P/PV	P/CDS
HOMAN	- SHPBLDG	1/78	0	1935	2400	3120	400	4260
		2/78	0	1975	2470	3275	399	4300
		3/78	0	1590	2115	3010		3380
		4/78	0	1715	2265	3255		3690
		5/78	5	1830	2405	3470		3970
		6/78	20	1910	2505	3625		4195
		7/78	30	1915	2520	3690		4330
		8/78	45	1845	2460	3685		4400
		9/78	70	1740	2365	3630		4420
		10/78	95	950	1580	2870		3745
		11/78	120	1075	1705	3025		3985
		12/78	145	1235	1870	3200		4230
		1/79	170	1400	2025	3370		4445
		2/79	195	1560	2175	3525		4650
		3/79	225	1730	2325	3675		4850
		4/79	255	1890	2460	3800		5010
		5/79	285	2030	2565	3880		5115
		6/79	315	2130	2625	3900		5155
		7/79	350	2165	2610	3825		5100
		8/79	385	2140	2535	3680		4965
		9/79	420	1620	1965	3025		4315
		10/79	455	1685	0	2645		3940
		11/79	495	1730	0	2580		3870
		12/79	535	1730	0	2475		3750
		1/80	570	1665	0	0		2915
		2/80	610	1545	0	0		2750
		3/80	650	1385	0	0		2535
		4/80	695	0	0	0		1770
		5/80	735	0	0	0		1735
		6/80	780	0	0	0		1685
		7/80	830	0	0	0		1635
		8/80	875	0	0	0		1585
		9/80	915	0	0	0		0
		10/80	945	0	0	0		0
		11/80	965	0	0	0		0
		12/80	990	0	0	0		0
		1/81	1020	0	0	0		0
		2/81	1050	0	0	0		0
		3/81	1075	0	0	0		0
		4/81	1095	0	0	0		0
		5/81	1105	0	0	0		0
		6/81	1120	0	0	0		0
		7/81	1135	0	0	0		0
		8/81	1140	0	0	0		0
		9/81	1150	0	0	0		0
		10/81	1160	0	0	0		0

Figure VIIId

SHIPBUILDING MANPOWER REQUIREMENTS
****

APRIL 30, 1979

SHIPYARD		DATE	NAV	PVT	CDS	P/NAV	P/PVT	P/CDS
HOMAN	- SHPBLDG	11/81	1165	0	0	0	0	0
		12/81	1170	0	0	0	0	0
		1/82	1170	0	0	0	0	0
		2/82	1170	0	0	0	0	0
		3/82	1170	0	0	0	0	0
		4/82	1165	0	0	0	0	0
		5/82	1160	0	0	0	0	0
		6/82	1150	0	0	0	0	0
		7/82	1135	0	0	0	0	0
		8/82	1110	0	0	0	0	0
		9/82	1080	0	0	0	0	0
		10/82	1050	0	0	0	0	0
		11/82	1015	0	0	0	0	0
		12/82	975	0	0	0	0	0
		1/83	935	0	0	0	0	0
		2/83	890	0	0	0	0	0
		3/83	835	0	0	0	0	0
		4/83	785	0	0	0	0	0
		5/83	730	0	0	0	0	0
		6/83	680	0	0	0	0	0
		7/83	625	0	0	0	0	0
		8/83	0	0	0	0	0	0
?								

Figure VIIId cont.

B. MOB - Mobilization Studies

The Mobilization group is used for Interagency Maritime studies in policy efforts, to determine if an adequate mobilization base exists for the purpose of national defense and for use in national emergency,

The program modules and data banks are used on an average, once a year. Both are highly specialized to determine if there is sufficient shipbuilding facilities, ship repair facilities, a workforce for activation, conversion, repair of Navy combatants, and commercial ships to respond to a mobilization scenario.

The MOB data bank is the largest volume data bank in SEAS. It is composed of approximately 4,000 ships and resides on tape until a mobilization study occurs. The information in the data bank will change significantly for each study, due to the different criteria incorporated in the studies.

The National Defense Reserve Fleet (NDRF) data bank used with mobilization studies, also resides on tape. It is relatively small compared to the MOB and SPAM data banks.

The program modules also reside on tape until a study occurs. All modules are interactive, therefore the requested information is readily available. The information is produced immediately in a report or graphic format on 81/2" X 11” paper.

Examples of the program modules capabilities follow:

PMACCN - A module designed to provide either a graphic manpower workload distribution curve or a report for four categories: Activation, Casualty/Repair, Commercial, and Navy.

PMOBINY - A module designed to tabulate ships by a specified key event date on a monthly basis. The five key event dates are: (1) award of contract, (2) start of fabrication, (3) keel, (4) launch, (5) delivery.

PMOBIN2 - A module designed to tabulate ships by a specified key event date on 6-month intervals. The five key event dates are: (1) award of contract, (2) start of fabrication, (3) keel, (4) launch, (5) delivery.

PSNDRP - A module designed to select data from the National Defense Reserve Fleet data bank.

PSREG - A module designed to select data from the Mobilization Data Bank.

PSTEEL - A module designed to provide a graphic steel (short tons) distribution curve or a report.

ULTZAT - A module designed to provide a Building Position Availability Report, based on existing and proposed contracts.

c. UTILITY ROUTINES

The utility modules are designed to perform relatively straight forward tasks. Such tasks are: creating data files, verifying dates, adjusting dates, shifting data, sorting data and assigning steel to vessels.

PASTEEL - A module designed to assign a steel value to vessels according to the type vessel.

PDATE - A module designed to adjust the five key event dates, earlier -or later than the current dates.

PDSHIP - A module designed to give the user a method to create data files for reactivation ships.

PEDIT - A module designed to verify the-key event date.

PSHIFT - A module designed to shift each link of data, in a data file, one position to the left.

PSORT - A module designed to sort several data files into one data file, according to one of the six selected key event dates.

D. TITLE XT

Title XI is a group of Management Data Query (MDQ) program modules designed to provide the status of Title XI applications. Title XI applications are submitted to MarAd for approval, disapproval or withdrawal.

Principal Characteristics Report - A quarterly publication reporting hull characteristics information of the Title XI applications from January 1977 to, present. The report is intended for the Division of Naval Architecture.

Financial Status Report - A quarterly publication reporting financial status information of the Title XI applications from January 1977 to present. The report is intended for **the** Office of Ship Financing Guarantees.

Project Status Report - A monthly publication reporting project stat-us information of the Title XI applications from January 1977 to present time The report is intended for the construction representative, supervisors, and other personnel who are directly involved in Title XI applications.

Print 11 - A module designed to extract data from the Title XI data bank in any format that the user desires.

TWO other MDQ program modules are used to address such issues as: the number of U.S. ships under construction from a specified time frame by vessel type, deadweight and contract value; the number of vessels over 1,000 gross tons, by shipyard, built between two specified dates.

The following two modules have these capabilities and more:

PTABNCON - A module designed to provide tabular reports in variable formats for vessels under construction. A maximum of **15 character is tics are** available in describing each vessel. **A** report may consist of all vessels

over 1,000 gross tons. Another report may consist of a particular type vessel (LNG or Tanker) delivered in a specified time frame.

PTABCONV - A module designed to provide tabular reports in variable formats for vessels under conversion or already converted. A maximum of 15 characteristics are available in describing each vessel. A report may consist of vessels under 1,000 gross tons;

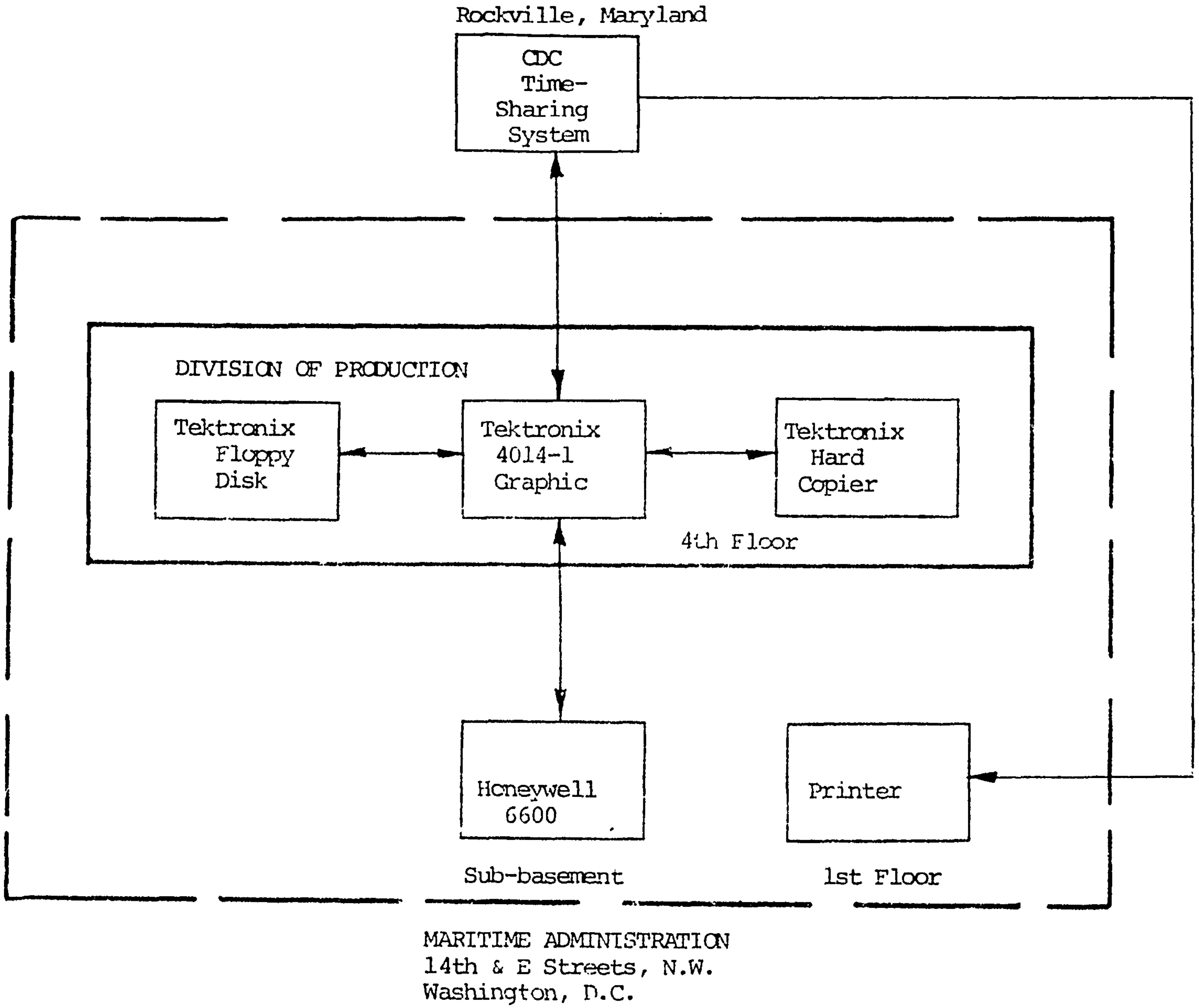
IX. HARDWARE CONFIGURATION

Review Figure Dl for an overview of the hardware configuration. The Division of Production's personnel are responsible for collecting, maintaining, and distributing all data concerning SEAS. They are also responsible for' any special studies, reports, or any other information the model generates. Therefore, they are considered the main user.

They have three pieces of Tektronix equipment located in their immediate area: (1) A Graphic Display Unit (4014-l), (2) A Flexible Disc Memory Unit (4921) and (3) A Hard Copier Unit (4631). The Graphic Display Unit is used to communicate with either the in-house Honeywell computer or the Control Data Corporation (CDC) Time-Sharing System, located in Rockville Maryland.

On occasion, there is a need to transfer a data file from the CDS Time-Sharing System to a printer. This function is accomplished via the CDC Time-Sharing System to the CDC Batch System, known as Cyberlink Note in Figure Dl, the location of the terminal (fourth floor) and the printer (first floor).

During a mobilization study certain reports contain classified information, therefore special handling procedures are required, and these will not be discussed. The teleprocessing communications currently being used is 1200 BAUD.



Rockville, Maryland
CDC Time-Sharing System
DIVISION OF PRODUCTION
Tektronix Floppy Disk
Tektronix 4014-1 Graphic
Tektronix Hard Copier
4th Floor
Honeywell 6600
Printer
Sub-basement
1st Floor
MARITIME ADMINISTRATION
14th & E Streets, N.W.
Washington, D.C.

Figure IXa

X. APPLICATIONS OF THE SEAS MODEL

Typical CDS Budget Request

Shipyard workload impact for outyear programs must be projected to document the CDS budget requests. An objective of the CDS program is to maintain an adequate shipbuilding industry that will meet the mobilization requirements and be adequate for the commercial and national security shipping requirements. All of the current 24 private shipyards in the Active Shipbuilding Industrial Base are needed to meet this goal. Additionally, all of the other yards in the repair base are needed for the short term emergency scenario. The 24 shipyards currently in the Active Shipbuilding base are listed below. Estimates of continuous stable peacetime workforce levels that will provide productive use of current facilities are made. Mobilization staffing requirements for an extended war have been estimated during a recent study to be much higher than those shown. The following yards participate in the active shipbuilding base and the aggregate workforce levels are shown.

Alabama DryDock & Shipbuilding Co.
American Ship Building Co. Lorain., OH
Avondale Shipyards, Inc.
Bath Iron Works Corp.
Bay Shipbuilding Corp.
Bethlehem Steel Corp., San Francisco, CA
Bethlehem Steel Corp., Sparrows Point, MD
Equitable Shipyards, Inc.
General Dynamics Corp., Groton, MA
General Dynamics Corp., Quincy, MA
Levingston Shipbuilding Co.
Litton Industries, Ingalls Shipbuilding Div.
Lockheed Shipbuilding & Construction Co.
Marinette Marine Corp.
Maryland Shipbuilding & Drydock Co.
National Steel & Shipbuilding Corp.
Newport News Shipbuilding & Dry Dock Co.
Norfolk Shipbuilding & Drydock Co.
Peterson Builders, Inc.
Sun Shipbuilding & Dry Dock Co.
Todd Shipyards Corp., Galveston, TX
Todd Shipyards Corp., Houston, TX
Todd Shipyards Corp., Los Angeles, CA
Todd Shipyards Corp., Seattle, WA

Total Stable Peacetime Workforce Level	110,000
Total Production Peacetime Workforce Level	**81,550**

The following graph “Shipbuilding Tndustry Workload Projection” depicts the employment scenario for the future years. Specifically examination of the graph shows the following:

a) **For the 24 yards in the Active Base workforce levels are** shown in equivalents which compensates for absenteeism, vacations, and overtime.

b) Repair and non-ship work employment has been approximately **13,000.** For convenience this value is straight lined across the graph. With new construction work decreasing it is anticipated that some of these yards will increase repair activity.

c) The solid line represents workforce levels **necessary to complete all** new construction [Navy, private, and CDS) currently under contract.

d) Loaded on top of the firm work is a 5-year Navy building program of approximately 23 ships per year.

e) After the Navy building program, the private construction forecasts, obtained from market surveys, are loaded.

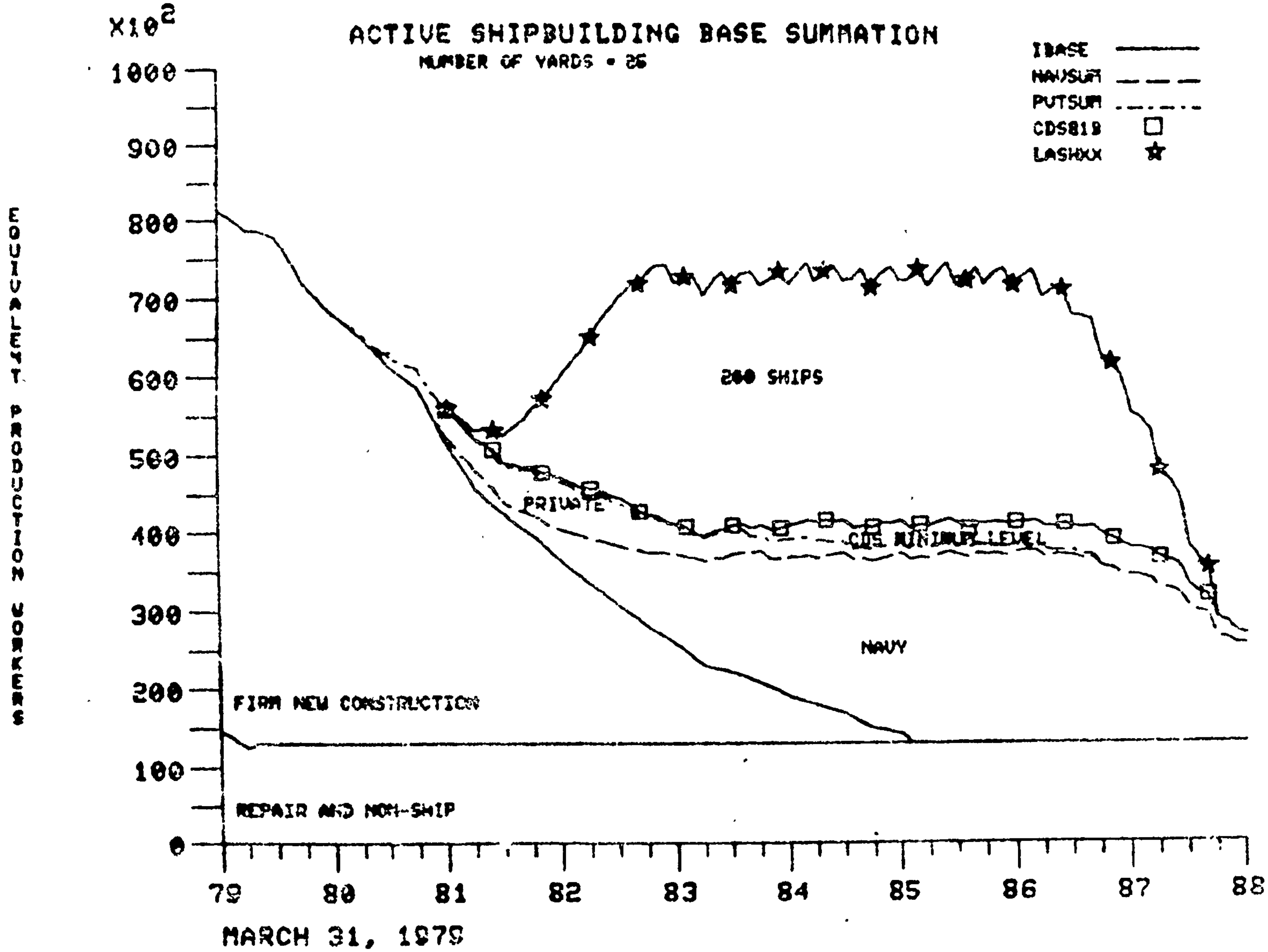
f) A typical low level budget request could contain the following projected vessels :

	80	81	82	83	84	85
LASH	I		2	2	2	2
CONTAINER SMALL			2	2		3
CONTAINER LARGE					2	

This is plotted on the curve using the □ symbol.

g) For example, 200 LASH type vessels were spread over the **5-year 80** thru 85 to examine the magnitude of shortfall from a stable production

SHIPBUILDING INDUSTRY WORKLOAD PROJECTION



SOURCE: SHIPYARD DATA FROM FORM MA-??? WHEN PROVIDED
OFFICE OF SHIP CONSTRUCTION, MARITIME ADMINISTRATION

Figure Xa

employment level of 83,100. The use of LASH type vessels is not intended to portray a shortfall of LASH ships in the fleet, but to provide a planning wedge of national cargo vessels. Two hundred LASH ships produces a level condition at around 73,000 still somewhat short of the goal, yet leaving enough slack to maintain competition. These are plotted using the * symbol.

PROPOSED CARGO PREFFRENCE LEGISLATION OF 1977

Another good example of SEAS function and role in policy analysis can be seen in the assessment of United States shipbuilding capacity for cargo preference legislation done in 1977.

During that time, considerable emphasis was being placed upon an assessment of the capacity of the United States shipbuilding industry. We had seen several studies that superimposed a number of assumptions upon the industry with a subsequent evaluation of the ability to accomplish the required work. There were also on-going individual minianalyses being done on a yard-by-yard basis to determine the adequacy of a particular contractor's ability to perform construction to his contract dates. All of this provided the basis for answering the question, "what is the amount of tanker tonnage that the industry could reasonably he expected to construct if cargo preference legislation is enacted?"

Before any analysis could be done, it was first necessary to define shipbuilding capacity. Shipbuilding capacity is a general term that can be very complex or very simple depending upon the context in which it is used. Annual cargo capacity tonnage construction is the desired output. The most commonly mentioned and analyzed components of a capacity assessment are the workforce and facility constraints. Refore developing those areas,

it should be mentioned that a number of other factors such as profitability, management talent, and component availability contribute to the industry's health, viability, and future well being. These should not be forgotten as part of the shipbuilding capacity of this nation.

Profit and the ability to make a profit is an important consideration. This is closely related to capital investment. one may ask how this is related to shipbuilding capacity. It is apparent that many of our shipyards have made significant capital investments in facilities over the last 10 years. Many of these investments were in anticipation of and in reaction to the tanker construction boom of the early 1970's. The point is not that we have excessive untied capacity; we did not in 1977. Rather, the point is that industry will invest and expand to meet the market if there is a profit to be made.

Another factor contributing to the industry capability and capacity to produce ships is the small hut highly experienced-and competent core of shipyard management talent that runs the nation's -shipyards. These people could Fe considered to be a national asset, and they definitely contribute to capacity. If increased capacity is desired, training of more people in shipbuilding would be a wise investment for the nation.

The component industry is also an often overlooked aspect of producing ships. Within recent memory are delays and disruption problems to ships under construction for the lack of valves, air compressors, propellers, gears, steel plates, welding wire, and castings to name a few. Supplier industry component lead times doubled and tripled during the 'tanker boom of the mid 7o's. This may very well be the critical path constraint for any significant expansion of the industry.

A value for capacity of the shipbuilding industry is really a nebulous quantity, only significant for a point in time evaluation. To have useful meaning, it should he used only when the criteria and assumptions are explained and understood. The overall capacity is flexible by the very nature of the business. To see this, one **has** to only examine the remarkable advances made in ING ship construction during a relatively short period by U.S. shipyards .

To answer the question of cargo preference tonnage construction capability, both facilities available and the workforce constraints must be analyzed in conjunction **with** each other. To do **this,** a forecast of the ships to be built is made and schedules and the workforce estimates are developed for each ship type. Ships to be built are scheduled into the building positions available at each yard behird or in consideration of the base workload under contract. Workforce curves are developed depicting the loading of direct equivalent workers required per month to build the ships loaded into the Vard. And finally, **ships** are rescheduled or juggled in an iterative process to eliminate unrealistic peaks and valleys in the yard workforce **much the same** as shipyard management would do.

The following assumptions were applied to yield a realistic estimate of the maximum deadweight tonnage that could Fe constructed t0 meet the demand for tankers under a cargo preference program:

1. **The current Navy5-year shipbuilding plan was loaded on top of the** base workload. This plan reflects projected procurements that are relatively well defined and fit into **the** overall defense plan. There is a high degree of probability that this work will be awarded and therefore it is loaded into the respective shipyards first,

2. Next in priority for way space is the commercial 5-year projection developed by MarAd's Office of Policy and Plans. This plan considers both CDS and private construction with the development of a high, best, and low ship mix scenarios. The best estimate with some minor variations is used to load the individual yards.

3. The maximum direct equivalent vard workforce levels were limited to current levels or allowed to expand based upon historical peacetime data and an assessment of each yard's individual situation. In the face of the workforce problems that many yards have experienced in the 1970 ' s and with al1 the inherent turnover and productivity losses caused by the build ups, shipyards recognized their maximum levels for doing efficient business, and were loaded according to those levels.

4. The remaining capacity after assignment of the Navy and commercial 5-year plans was assigned to construction of cargo preference tankers.

5. A range of tanker sizes were utilized to maximize the tonnage output each yard could construct. These varied 'from small feeder vessels of approximately 30,OOO DWT up to 600,000 DWT being conceptualized by Newport News at that time.

6. If legislation had been enacted at that time, the earliest possible ship construction contract awards would have been in July 1977. However, July 1977 award dates are arbitrary and short term shifts would not affect the conclusions. Contract award assumptions subsequent to July 1977 were contingent upon building position availability in individual shipyards.

7. Tanker sizes up to and including a conceptual 6O0,000 DWT size possible at Newport News were considered. This allowed the maximum tonnage to he built and also assumed that deepwater port facilities such as SFADOCK and Loop will he on line in the early 1980's.

8. An attempt to load each shipyard facility on a reasonable way schedule was made. Some overlaps are inevitable when scheduling bypothetical building programs. Although these schedule overlaps have been kept to a minimum, it is assumed that shipyards can develop individual work-around plans to accommodate some overlaps as they have done in the nast.

9 This study includes an estimate of present capability only. Capital improvements which could increase capacity are likely to occur if a. significant (argo Preference law is enacted.

The result of the iterative analysis process were tabulated to show the industry capacity in three ways: the number and types of ships; the tanker deadweight tonnage ; and a total industry workforce projection.

The ship mix finally assigned to the projected yards based upon the available building positions and manpower consisted of 165 unawarded ships in the Navy program through 1982, (much larger than now planned), 110 non-tanker commercial ships in the MarAd forecast and 127 tankers for cargo Dreference. No attempt was made to project requirements for skilled crafts within the workforce. However, it is a good possibility that this could further restrict the capacity. The summation of cargo preference tonnage with the total deadweight per vear and cumulative deadweight of 16,270,000 DWT by 1985 based upon deliveries of the projected cargo preference tankers

is shown in the following table. It should be noted **totally** there are seven shipyards that are not currently building large ships. These yards have the facilities to build the vessels as indicated and have all been contacted to confirm their interest in new construction should the market for new tankers become available. Tndustry workload to accomplish these construction projections was estimated by SEAS with a workforce build up to around 190,000 total industry by the end of 1980 being reasonable and attainable at that time.

SUMMATION OF SEAS OUTPUT FOR CARGO PREFERENCE

Estimate of Shipyard Capacity to Build Tanker Tonnage

	Delivered by END 1980		BY End 1985	
Large Shipyards now Engaged in New Ship Construction	(1) T190	‘190,000	(11) T190	2090,000
	(5) T120	600,000	(10) T265	2650,000
		180,000	(15) T120	1800,000
	(I) T225	225,ooo	(6) T600	3600,OOO
			(7) T225	1020,000
				1575,000
	TOTAL	1,195,ooo DWT		12,735,ooo DWT

	Delivered BY End 1980		BY End 1985	
smaller shipyards that have capability and have Shown interest	(3) T30	90,000	(9) T30	270,000
	(3) T35	105,000	(13) T35	455,000
	(2) T40	80,000	(7) T40	280,000
	(3) T60,	180,000	(13) T60	780,000
	(2) T70	140,000	(7) T70	490,000
	(1) T90	90, 000	(6) T90	540,900
	(1) T120	120,000	(6) T120	720,000
	TOTAL	805,000 DWT		3,535,000 DWT
GRAND TOTAL		2,900,QOO DWT		16,270,000 DWT

SHIPYARD CERTIFICATIONS

Before a construction- differential. subsidy contract can be executed between the Maritime Administration and a construction yard, the Director of the Office of Ship Construction must certify that in his opinion the contractor has the capabilities in terms of workforce, facilities, management, and technical capability to perform under terms of the construction contract. This certification cannot be done without reliable data and a critical evaluation of the current status of work in the yard's contract orderbook. One of the major sources of this information is SEAS. Through the reports outlined earlier in this paper, current status can be examined. Frequently MarAd may already have a construction representative in the yard to monitor on -going CDS contracts. His on the spot experience and familiarity is useful to the certification. Often a production analyst is sent to the yard's facility for an on-site visual update of the proposed construction facilities and review of the construction process planned. These on-site inspections are extremely valuable in keeping the analyst up to date with ship construction techniques and in touch with cognizant shipyard personnel who may be contacted when problems arise later in the contract.

The four components of the certification are considered. First, workforce availability is of the utmost importance. If a build up is required for the proposed work, an attainable rate must be demonstrated. Historical comparisons are used for assessment of the validity and likelihood of a yard's ability to attain the required build-up rate. Consideration must be made of the source or sources of skilled workers. Recently, one yard was denied a contract by MarAd on the basis that a facility did not actually have a skilled workforce available to draw upon. The facility itself was to be

opened and developed just for the contract and it was determined that the lack of a skilled workforce made it highly unlikely that the contractor would perform under the contract and meet a delivery schedule for the vessel. SFAS has the ability to overlay the proposed-work on the current orderbook and examine the workforce demand. The following graph- shows a hypothetical shipyard's current orderbook with three large tankers and six naval auxiliaries being proposed. The workforce requirements are shown so that a build-up of the current employment is required. However, the 2,000 equivalent worker increase in a period of 21/2 years may have been done before and certainly could be assumed to be reasonable.

Facilities availability is the second areas of concern. Although many other areas of the yard may be critical, SEAS only looks at building positions unless the analyst has a reason to-suspect another area is on the critical path for construction.

The next chart shows our hypothetical yard's building position utilization with the proposed Navy and commercial contracts superimposed after the firm work. Many times yards will plan work too tightly for an individual facility. SEAS provides MarA d with-this information in advance,

The third and fourth areas are management and technical capability The analyst must investigate and report his findings in these areas to complete the certification. SEAS cannot contribute to the certification in these areas.

FUTURE DEVELOPMENT

Projection of workforce requirements by major craft skills

A project has been underway for some time to enhance the capabilities of SEXS by providing the capability to project workforce requirements by the major craft skills. Currently SEAS has the capability of distributing proposed direct production workforce requirements to build a ship over a standard distribution curve. This curve was jointly generated and subsequently developed for the SPAMM model by the Engineering Computer Group and the Division of Production about 5 years ago. **This model has served Marad's** interest well and will continue to provide reliable planning and scheduling information for management's use.

However, if this capability could be expanded to include specific trade demands the SEAS model could be a much more dynamic tool.

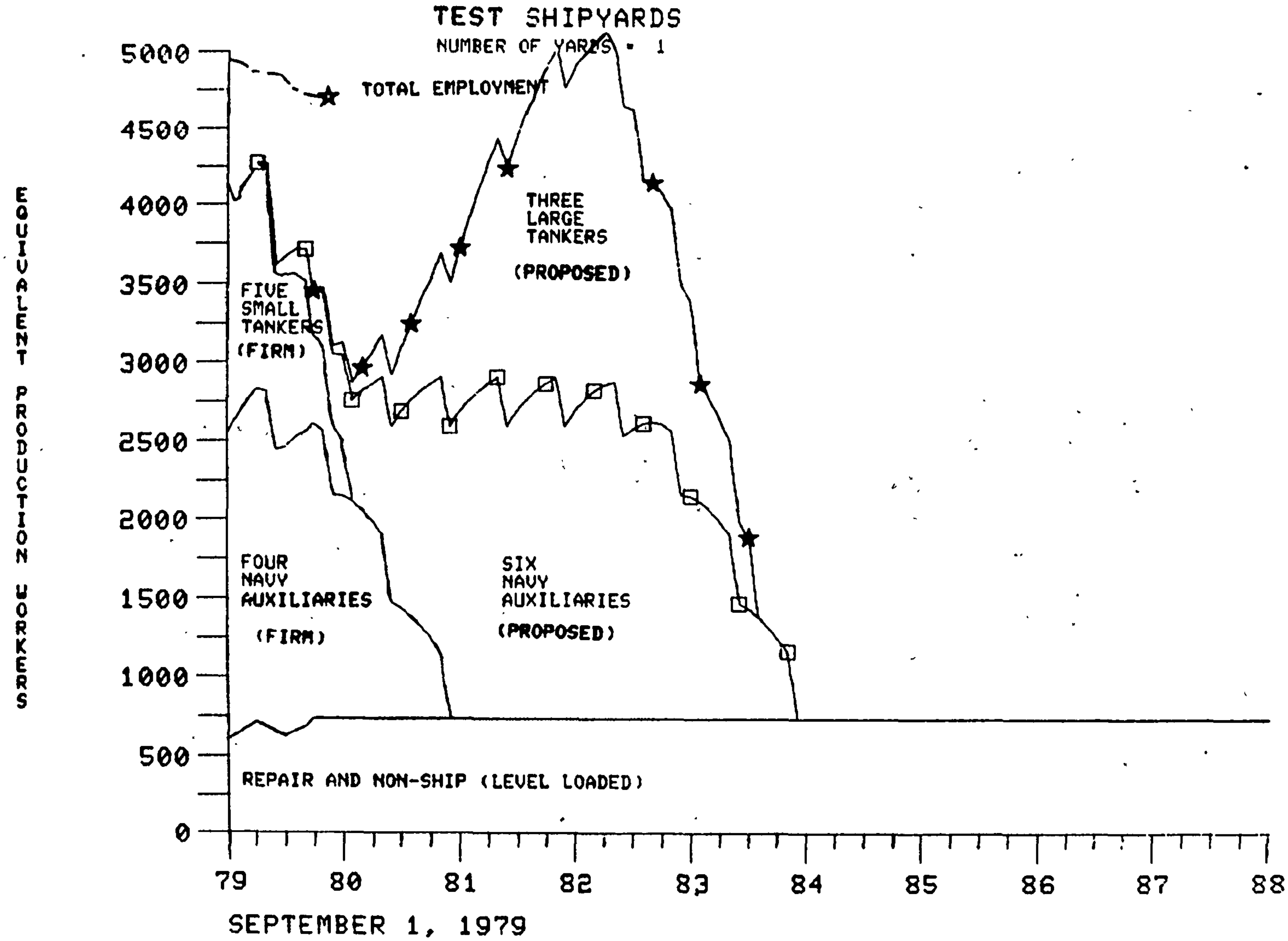
Without question there is a need to develop industry requirements for reliable workforce projections (in the areas of commercial and Navy Shipbuilding and Repair) on both a normal peacetime and national emergency basis.

We propose to expand our present SEAS model to enable us to project workforce demand curves by the specific skills categories listed below:

1. Electricians
2. Welders
3. Sheetmetal Workers
4. Inside/Outside Machinists
5. Pipefitters
6. Electronic Mechanics
7. Riggers
8. Shipfitters
9. Loftsmen
10. Boilermakers
11. Painters
12. All Other

This development would be immediately useful to the Office of Labor and Training in meeting the overall goals of their project relating to skills training and establishment of shipbuilding job carp centers.

SHIPBUILDING INDUSTRY WORKLOAD PROJECTION



SOURCE: SHIPYARD DATA FROM FORM MA832 WHEN PROVIDED
OFFICE OF SHIP CONSTRUCTION, MARITIME ADMINISTRATION

Figure Xb

TEST SHIPYARD

BUILDING POSITION UTILIZATION

SEPTEMBER 1, 1979

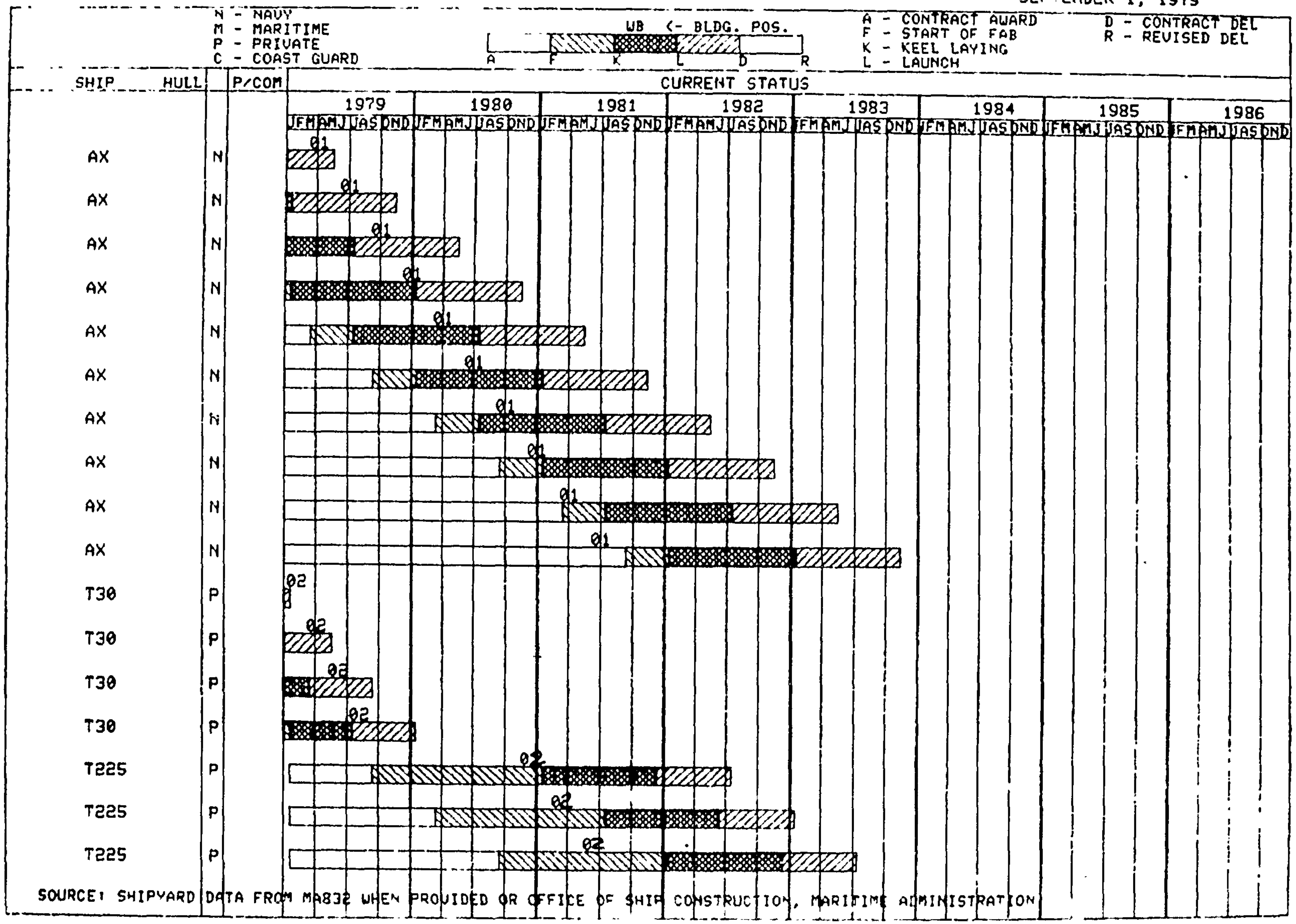


Figure Vc

To do this, data is needed for individual ships so that the skill categories and shapes for specific skill distributions can be generated. It is intended that the shapes can be easily changed or chosen to match individual circunstances. Some individual yards have offered pieces of the needed information. However, there seems to be a data void that must be overcome before this enhancement can be realized. When data becomes available it will be put on a percent worker/percent building time basis from start of construction to delivery so that only the shape of the distribution is actually being analyzed. By using the percent/percent basis no one yard's specific manpower levels can be compromised to a competing shipyard.

To get these curves we will gather data by the broad ship type categories of cargo, tanker, naval auxiliary and naval combatant. A program is being planned that will utilize each ship's individual skill curves, calculate the areas under the curve (which is essential to obtaining the percentage of the total job by trade), and curve fit a standard curve to the sample of data which will produce a representative skill trade production forecast.

SEAS will then only need a specific work days estimate and a proposed building schedule to output a forecast of the workforce demand by skill trade.

It would be tempting to include all major ship categories in the model from the very beginning. We intend to develop a pilot program which focuses on one specific ship type. After demonstrating the model capabilities, it will be only a matter of plugging in information for other categories of vessels to expand the model as needed and as more and more data resources become available. Within a relatively short period of time, we could have something concrete to exhibit to the various entities who would have use

for such information, thereby mitigating any skepticism or hesitation on the part of data sources to release needed information. This would facilitate expansion of the model.

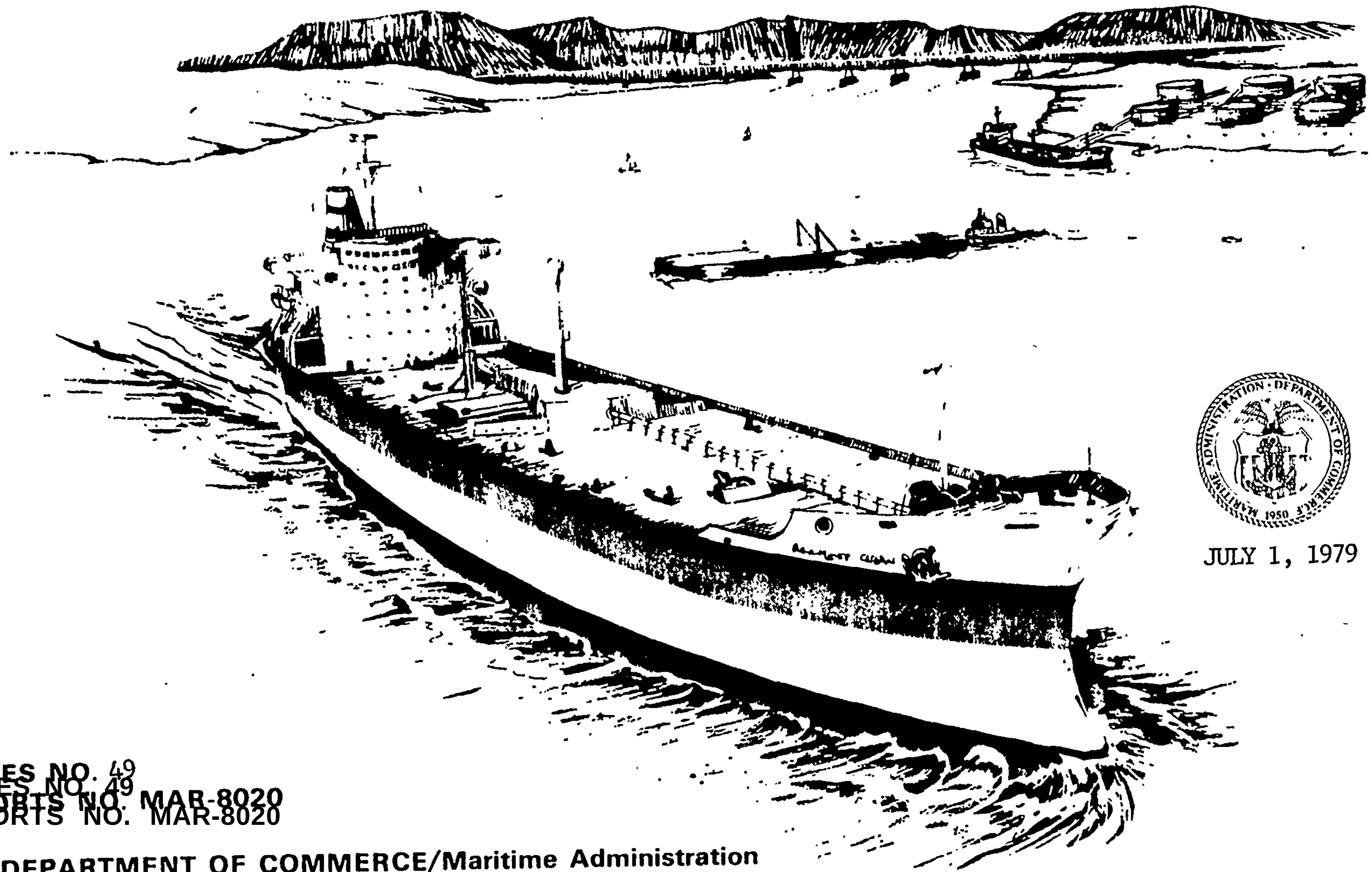
We believe this proposed model will greatly improve our response to the many inquiries and surveys we respond to on a continual basis from outside sources as well as those generated from within MarAd. Also, our management planning capabilities will be greatly enhanced.

In summary, a methodology exists to further develop and enhance the SFAS model to provide a capability for projecting workforce demand curves by specific skill category. Initial programming has been accomplished and data sources are being investigated.

Appendix A - Example Quarterly Shipbuilding Status Report

Appendix B - Five Year Shipbuilding Plans

STATUS OF MAJOR SHIPBUILDING IN U.S. COMMERCIAL SHIPYARDS



JULY 1, 1979

ISSUES NO. 49
REPORTS NO. MAR-8020

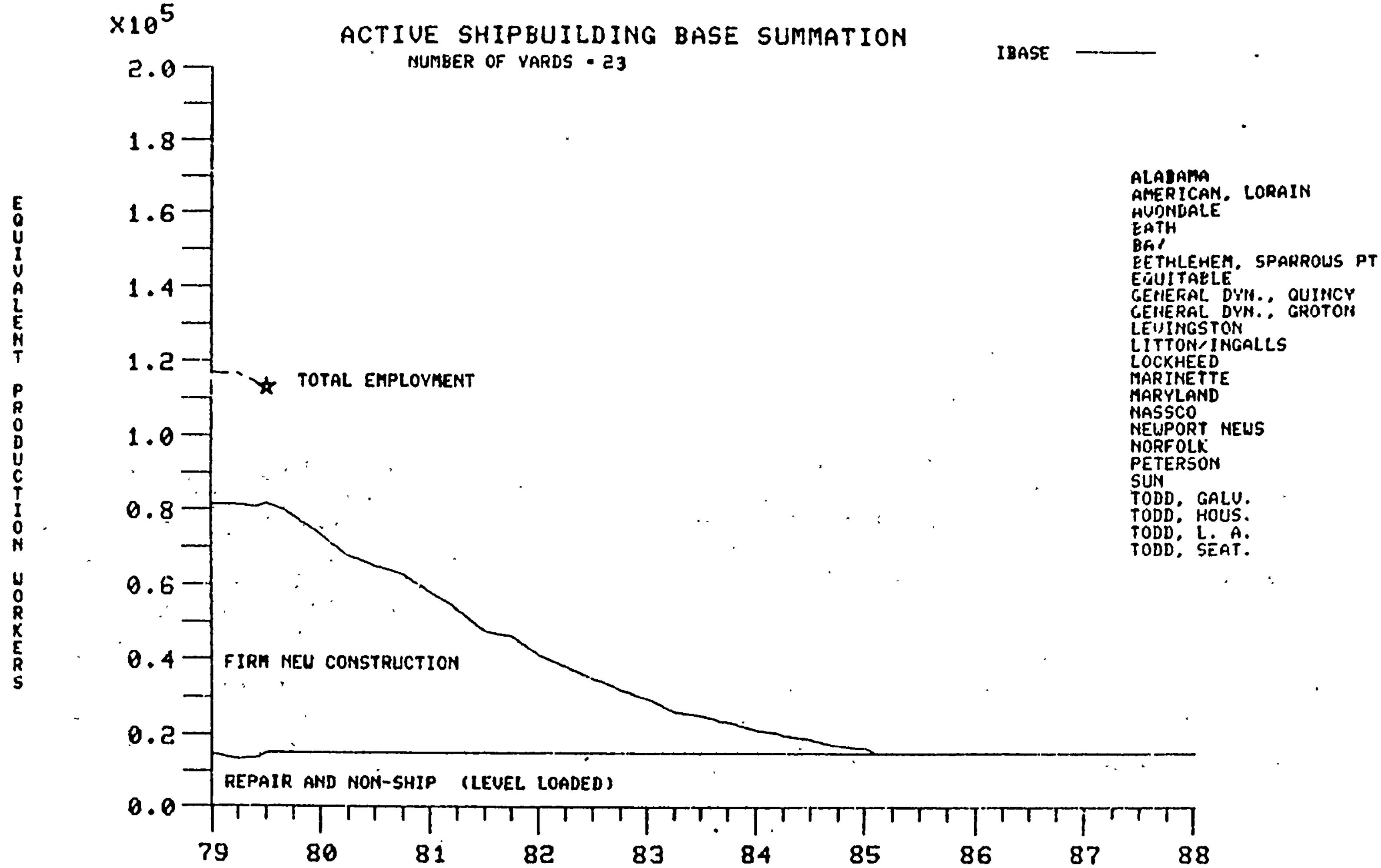
U.S. DEPARTMENT OF COMMERCE/Maritime Administration

FOR OFFICIAL USE ONLY

THIS REPORT, "STATUS OF MAJOR SHIPBIULDING IN U. S. COMMERCIAL SHIPYARDS" IS PRIMARILY DESIGNED TO PROVIDE CURRENT INFORMATIN FOR MANAGEMENT ON THE STATUS OFSHIPBUILDING.IT DEPICTS GRAPHICALLY, THE COMPLETE ORDER BOARD OF EACH MAJOR SHIPYARD HAVING THE CAPABILITY TO CONSTRUCT SHIPS 475' LOA.x 68' BEAM AND OVER. INCLUDED ARE ALL KNOWN MARITIMF ADMTNISTRATION, NAVY, OTHER GOVFRNMENT AND PRIVATE CONTRACTS, FOR NEW OCEANGOING SHIPS AND ALL CONVERSION WORK TO OCEANGOING SHIPS HAVING A CONTRACT VALUE OF $ 1 MILLION AND OVER AND A SHIPYARD AVAILABILITY OF AT LEAST 6 MONTHS. ADDITIONAL INFORMATION INCLUDES DELAYS, PERCENTAGE OF COMPLETION AND TOTAL EMPLOYMENT WHICH IS SUPERIMPOSED ON THE WORKLOAD FOR EACH YARD.EMPl.OYMENT FOR THE LAST QUARTER SHOWN IS ESTIMATED AND WILL BE ADJUJSTED AS ACTUAL DATA IS RECEIVED. DELAY INFORMATION IS ALL INCLUSIVE, i.e., DELAYS DUE TO CHANGES AND EXTRAS REQUIRED BY OWNERS AS WELL AS PRODUCTION DELAYS BY CONTRACTORS DUE TO LABOR SHORTAGES, LATE MATERIAL DELIVERIES, STRIKES, ETC. THIS REPORT IS PUBLISHED QUARTERLY. MARAD AND PRIVATE WORK IS SHOWN AS SCHEDULED 6-30-79 NAVY WORK IS SHOWN AS SCHEDULED 6-l-79

PREPARED BY OFFICE OF SHIP CONSTRUCTION (CODE 723)

SHIPBUILDING INDUSTRY WORKLOAD PROJECTION



JULY 1, 1979

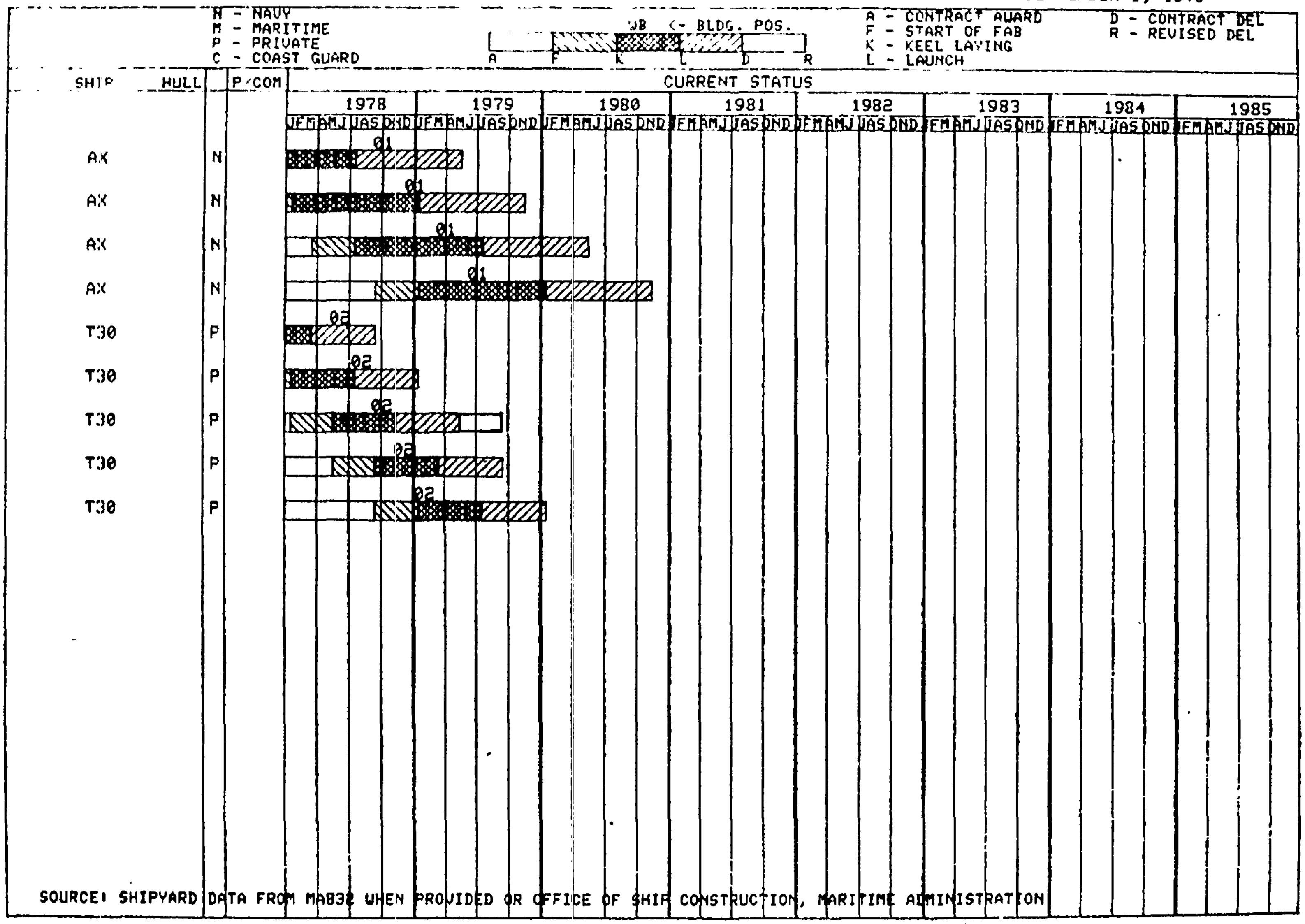
SOURCE: SHIPYARD DATA FROM FORM MA832 WHEN PROVIDED
OFFICE OF SHIP CONSTRUCTION, MARITIME ADMINISTRATION

FOR OFFICIAL USE ONLY

TEST SHIPYARD

BUILDING POSITION UTILIZATION

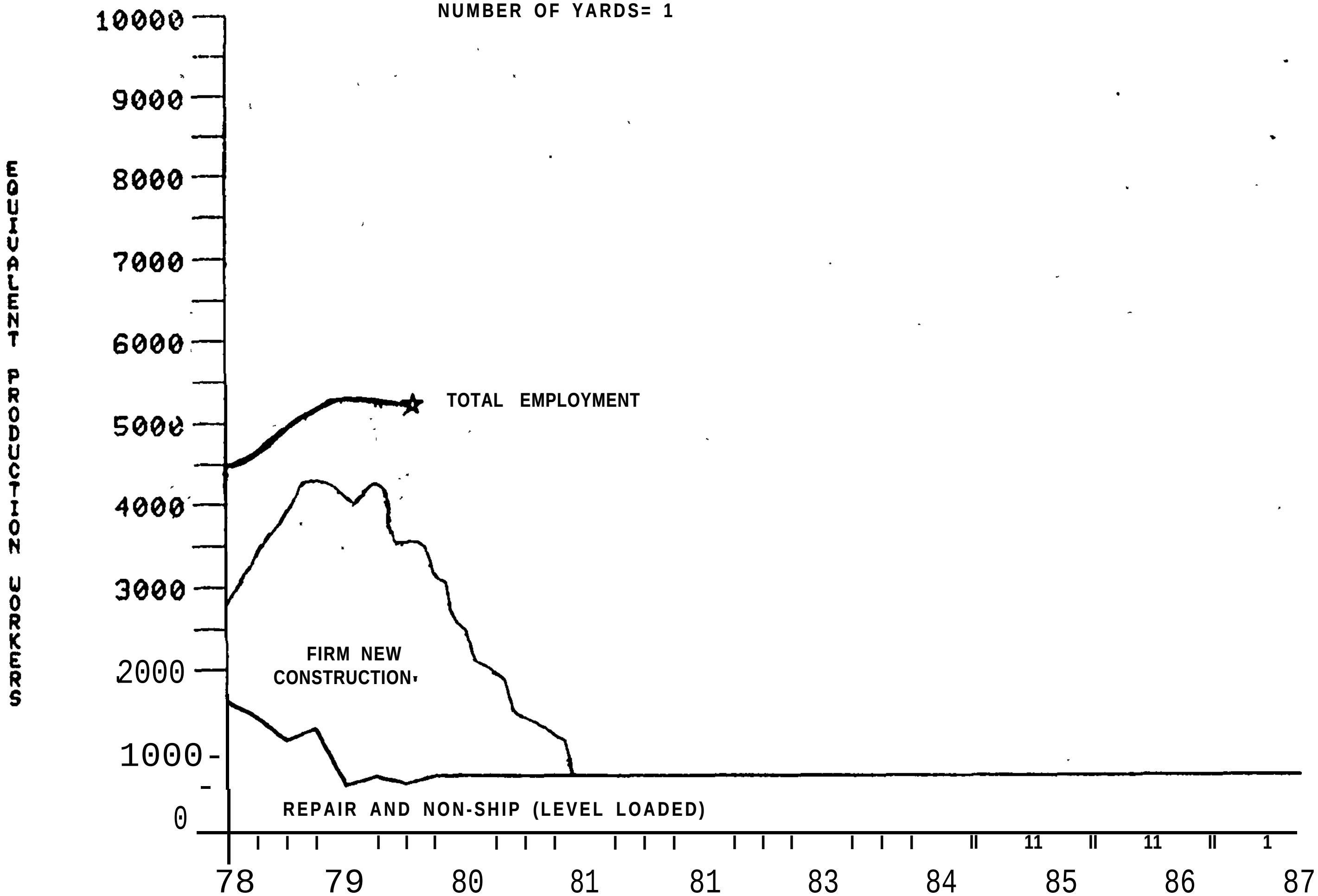
SEPTEMBER 1, 1979



SHIPBUILDING INDUSTRY WORKLOAD PROJECTION

TEST SHIPYARD

NUMBER OF YARDS= 1



SEPTEMBER 1, 1979

SOURCE SHIPYARD DATA FROM FORM MAR32 WHEN PROVIDED
OFFICE OF SHIP CONSTRUCTION, MARITIME (ADMINISTRATION

FORM MA-832
(8-78)

U.S. DEPARTMENT OF COMMERCE
MARITIME ADMINISTRATION

SHIPBUILDING ORDERBOOK AND SHIPYARD EMPLOYMENT
(With Projections for Completion of Firm Work Orderbook)

Date: August 27, 1979

Shipyard: Any yard ABC

This report is authorized by law 46 USC 1120 and 46 USC 1121. While you are not required to respond, your cooperation is needed to make the results of this survey comprehensive, accurate and timely.

Current Monthly Average of Total Plant Employees: 5371 Mo. August

Manpower: ☐ EQUIVALENT ☐ ACTUAL — Multiplier: 1.13

PRODUCTION WORKERS

		TOTAL PRODUCTION WORKERS	SHIPBUILDING: TOTAL CONSTRUCTION	SHIPBUILDING: MARAD	SHIPBUILDING: NAVY	SHIPBUILDING: OTHER FEDERAL	SHIPBUILDING: PRIVATE	SHIP REPAIR: TOTAL REPAIR	SHIP REPAIR: NAVY	SHIP REPAIR: OTHER FEDERAL	SHIP REPAIR: PRIVATE	NON SHIP WORK
		1	2	3	4	5	6	7	8	9	10	11
Current Monthly Average		3762	3027	717	1727	130	453	735	306	11	232	186
PROJECTION OF FIRM WORK												
Calendar Year -	Quarter 1											
	2											
	3											
79	4	3196	2466	420	1726	84	236	730	300	20	240	170
Calendar Year 80 -	Quarter 1	2759	2029	327	1489	0	213	730	330	20	240	140
	2	2068	1348	131	1150	0	67	720	400	20	200	100
	3	1470	750	0	750	0	0	720	400	20	200	100
	4	1240	520		520			720	400	20	200	100
Calendar Year 81 -	Quarter 1	720	0		0			720	400	20	200	100
	2											
	3											
	4											
Calendar Year -	Quarter 1											
	2											
	3											
	4											
Calendar Year -	Quarter 1											
	2											
	3											
	4											
Calendar Year -	Quarter 1											
	2											
	3											
	4											

NOTE: Column 1 = Column 2 + Column 7 + Column 11 Column 2 = Column [illegible] Column 7 = Column 8 + Column 9 + Column 10

USCOMM-DC 13136-P78

SCHEDULE OF CURRENT ORDERBOOK CONSTRUCTION DATES	Date: August 27, 1979
	Shipyard: Any Yard ABC

Respondent:	Position Title:	Phone:
Fred D. Wizzard	Manager, Production Analysis	202-377-4779

SHIP TYPE	BUILDER HULL NO.	AWARD	START FABRICATION	KEEL	LAUNCH	DELIVERY	BUILDING POSITION	PERCENT COMPLETE	REMARKS
AX	1101	11/7/76	10/6/76	7/1/77	7/14/78	5/15/79	01	100	NAVY
AX	1102	11/7/76	4/5/77	2/3/78	1/30/79	12/1/79	01	75	NAVY
AX	1103	9/21/77	3/17/78	7/17/78	7/2/79	5/28/79	01	69	NAVY
AX	1104	9/21/77	8/30/78	1/3/79	2/3/80	12/1/80	01	47	NAVY
T-30	1105	12/20/76	6/7/77	9/10/79	3/17/78	1/31/78	02	100	CDS
T-30	1106	12/20/76	11/30/77	2/19/78	7/11/78	1/30/79	02	100	CDS
T-30	1107	7/3/77	2/20/78	5/21/78	11/31/78	9/5/79	02	98	ST. GOVT
T-30	1108	9/16/77	5/30/78	9/10/78	3/17/79	9/19/79	02	81	PVT
T-30	1109	1/6/78	9/16/78	1/29/79	8/8/79	2/6/80	02	64	CDS
MISC. REPAIR ONGOING									
D7	699	7/15/79	-	-	-	9/6/79	PS	-	OVHL
BGG	725	8/30/79	-	-	-	10/7/79	PS	-	REPAIR
FERRY	14	7/3/79	-	-	-	8/16/79	DD 3	-	REPOWER
T-25	851	8/1/79	-	-	-	8/27/79	PS	-	REPAIRS

Form Terminology

For the purposes of this form, the following standard terminology has been established as a basis to maintain data consistency between participating data sources:

Ship Type - a designation which will clearly identify different ships under contract. For example

Ship Designation	Ship Type
265,000 DWT Tanker MA Design T10-S-101b	T10-S-101b
Fleet Oiler Navy Design AO Navy Hull Number 177	AO-177
80,000 DWT Tankers No Marad Subsidy	T-80

Start Fabrication - the date direct charging of production worker labor a specific hull occurs that will. sustain construction.

Keel - the date an identifiable section of the hull occupies a building position.

Launch - the date a building position is vacated by moving of a hull section and thus making available this position for another hull.

Percent Complete - the ratio of the total summation of the dollar value of all labor and materials utilized to the total dollar value of the contract or some other suitable ratio method of comparing the total value assessment of labor and material completion to the total value of labor and material required for the contract.

Building Position - the pier, way, basin, drydock or other facility location that is dedicated to either ship construction or conversion.

Production Workers - working foremen and all non-supervisory workers (including lead men and trainees) engaged in fabrication, processing assembling, inspection, handling, receiving, storage, packing, warehousing, shipping and other services

closely associated with the above production operations (exclusions are those workers engaged in construction of major additions or alterations to the plant, maintenance, repair, janitorial., watchman, administrative engineering, technical, supervisory, sales, recordkeeping and other related office services).

Firm Work - work that is contractually on the current orderbook.

Non Ship Work Column - all other production work not charged to an actual shipbuilding project, such as industrial products.

Marad Column - the production work charged only to Title V CDS ship construction or conversion (includes vessels under Title XI mortgage insurance only when Title V is also involved).

Private Column - the production work charged to any private, city, county, or state ship construction or conversion (includes all vessels with only Title XI mortgage insurance).

Other Federal Column - the production work charged to any other federal government ship construction or conversion (such as U.S. Coast Guard or National Oceanic and Atmospheric Administration, etc.).

Manpower (Actual or Equivalent) - select the most convenient type of manpower value that will be displayed for the average men in each period.
- actual men are the actual or planned personnel employment required.
- equivalent men are the total manhours expended (TME), either actual or planned, during a specified time frame divided by the total straight time (TSTHA) hours available per man during that same time frame. (i.e. equivalent men $= \frac{TME}{TSTHA}$)

Multiplier - the conversion factor (M, where M>l) that converts equivalent men into actual men.
(i.e. actual men = M x equivalent men3

Appendix B

Five Year commercial Shipbuilding Forecast
Fiscal Year of Award - July 1979

New Construction (Case I)	FY 79 (Unawarded)	FY 80	FY 81	FY 82	FY 83	FY 84	TOTAL
GLB10	–	1	–	–	–	–	1
GLB14	1	–	–	–	–	–	1
GLB23	–	–	–	–	1	–	1
GLB37	–	1	–	–	–	–	1
GLB60	1	1	2	1	1	–	6
DYB37	–	3*	5*	5*	5*	1*	19
CATUG/TKR	–	–	2	1	–	–	3
CNTR/RORO	–	–	–	–	2*	4*	6
CNTRL	1*	–	–	–	–	3*	4
T35	–	–	–	5[a]	–	–	5
T40	–	–	–	–	3	–	3
Sub-total	3	6	9	12	12	8	50
CASE II							
LNG	–	2*	4*	–	–	–	6
Sub-total	0	2	4	0	0	0	6
CONVERSIONS							
CNTR/RORO	–	2*	–	–	–	–	2
T35/JUMBO	–	1	1	1	1	–	4
T37/JUMBO	–	3	4	–	–	–	7
T50/RP	1	4	–	–	–	–	5
Sub-total	1	10	5	1	1	0	18
TOTAL	4	18	18	13	13	8	74

* Subsidized Vessels
a Possible reduction in number by two vessels

Legend

	Large Containership
CNTRL	Partial Container/RORO
LASH/CNTR	81b LASH/containership
CATU/TKR	Tug/Barge Tanker
LNG	125,000 cubic-meter LNG Ship

JUMBO -Jumboized with new forebody
RP- Repowered from steam to diesel propulsion.
GLB- Great Lakes BulkShip
DYB -Dry-BulkShip
T -Tanker

Note: All numbers indicate DWT in thousands, e.g., T-35 means 35,000-DWT tanker.

Navy Five Years Shipbuilding Forecast

May 10, 1979

New Buildings	Unawarded FY'79	FY'80	FY'81	FY'82	FY'83	FY'84	FY'85	Total
LSD-41	-	-	1	-	-	1	1	3
T-ARS	-	-	1	2	1	-	-	4
TRIDENT	-	1	1	1	1	1	2	7
SSN-688	-	1	1	2	1	2	-	7
FA-SSN	-	-	-	-	1	-	2	3
DDG 47	1	1	2	3	3	4	4	18
FFG	-	6	3	2	-	-	-	11
T-AO	-	-	-	-	2	2	-	4
MCM	-	-	-	1	4	4	-	9
T-AGOS	2	5	5	-	-	-	-	12
DDX	-	-	-	-	-	1	-	1
CV	-	1	-	-	-	-	-	1
T-ARC	1	-	-	-	-	-	-	1
Total	4	15	14	11	13	15	9	81
Conversions								
LPH	-	1	-	-	-	-	-	1
DDG-2	-	1	3	3	3	-	-	10
CV SLEP	-	-	1	-	1	-	-	2
T-AK	-	-	1	-	-	-	-	1
Total	-	2	5	3	4	-	-	14
Grand Total	4	17	19	14	17	15	9	95

LEGEND

AD	Destroyer Tender
CVV	Conventional Aircraft Carrier
CV SLEP	Aircraft Carrier (conversion)
	Experimental/Special Purpose Destroyer
s-47	Destroyer
DDG-2	Destroyer (conversion)
FFG	Guided Missle Frigate
LSD-41	Dock Landing Ship
MCM	Mine sweeper
SSN-688	Nuclear Attack Sumbarine
T-AGOS	Electronics Surveillance Ship
T-AK	Supply Ship (Conversion)
T-AO	Auxiliary Oiler
T-ARC	Cable Repair Ship
T-ATU	Oceangoing Tug
TRIDENT	Fleet Ballistic Missle Submarine
T-	For use by Military Sealift Command
F-	Being built for a foreign nation
FA-SSN	Nuclear Fleet Attack Submarine

AUTOPART, AUTONEST, AUTODRAW - SYSTEMS FOR INTERACTIVE GENERATION OF PRODUCTION INFORMATION

Paul F. Sorensen
Marketing Director
Shipping Research Services, A/S
Oslo, Norway

As Marketing Director, Mr. Sorensen is in charge of marketing information systems and consulting services offered by Shipping Research Services. He is a graduate of the Technical University of Norway with a degree in shipbuilding and marine engineering.

Mr. Sorensen was previously Head of Information Systems at Shipping Research Services. He has also held the positions of Head of Research and Development with the Aker Group, and Marine Surveyor with AALL & Company in Japan.

ACKNOWLEDGEMENT

The Author is indebted to the systems development team with members from SRS, CIIR and the Aker Group, for their contributions to the preparation of this paper.

SYNOPSIS

This paper describes AUTOPART, AUTONEST and AUTODRAW, a suite of new AUTOKON programs for parts definition, nesting, verification and general drafting. They are implemented in interactive graphics technology using a mini computer and a Tektronix 4014 storage tube for communication.

AUTOPART and AUTONEST may be used as a stand alone system providing N/C cutting information, partly replacing similar functions of the AUTOKON batch system. However, for shipbuilding the 3 modules should be seen as an integral part of the whole AUTOKON system, offering higher efficiency and increased flexibility in the production and of the process.

INTRODUCTION

The development of an "interactive AUTOKON" has been dealt with in a variety of presentations and papers at previous REAPS conferences. WE have explained the reasoning behind our development, the philsophy and consepts and we have even presented details on actual operating results. Fore those interested, reference is made to REAPS proceedings, from earlier years. So much has been written and spoken about interactive computer graphics application in general, that I assume the reader is familiar to the pro's and con's.

Our first exposure to a practical application in this technology was AUTONEST, started in 1974. It was a typical pilot project, which main purpose was to learn what this technology was all about. We learned that there was a long step from creating a picture that could be move around on the screen - to a down-to-the-earth useful and efficient production tool.

The concept for an entirely new technical information system, called "interactive AUTOKON" was developed in 1976/77, and has been continuosly subjected to further detailing, in terms of data base design and system design. Obviously we were faced with a pretty long term effort. But at the same time short term results in form of practical applications were demanded. This was not an easy balance.

We had an existing AUTOKON system, so we decided that the short term results should be made in such way that they could enhance the existing AUTOKON system, at the same time as being parts of the future interactive AUTOKON. Since lofting and work drawings still catered for 50-60% of the hours in design and work preparation of steel, and since we had already developed AUTONEST, we decided to concentrate the short term developments to make interactive production preparation tools.

AUTOPART, AUTONEST and AUTODRAW cover partcoding, nesting, verification and general drafting and are such tools. To place them in their right position in the AUTOKON "land scape", AUTOKON-79 is used as departure point. Exhibit 1 shows AUTONEST as an alternative function to NEST.

In Exhibit 2, AUTOPART and AUTODRAW have been added. As will appear later, AUTOPART has many of ALKON's basic functions, but does by no means replace ALKON in the overall AUTOKON context as an integrated design and production system. AUTODRAW has no parallell in the batch system, and should basically be considered major enhancement to the existing drawing facilities of AUTOKON-79.

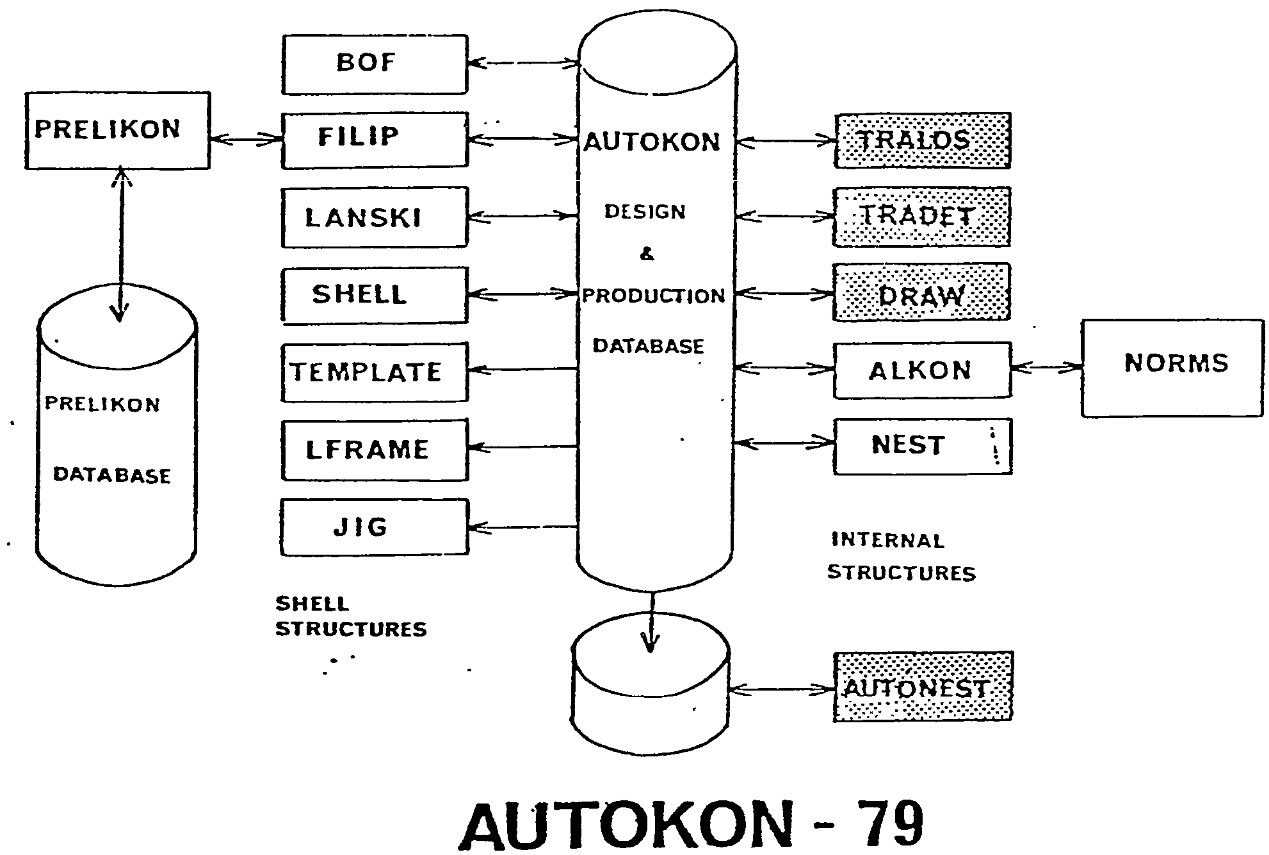


Exhibit 1

Layout of the AUTOKON-79 system, including the interactive nesting module AUTONEST.

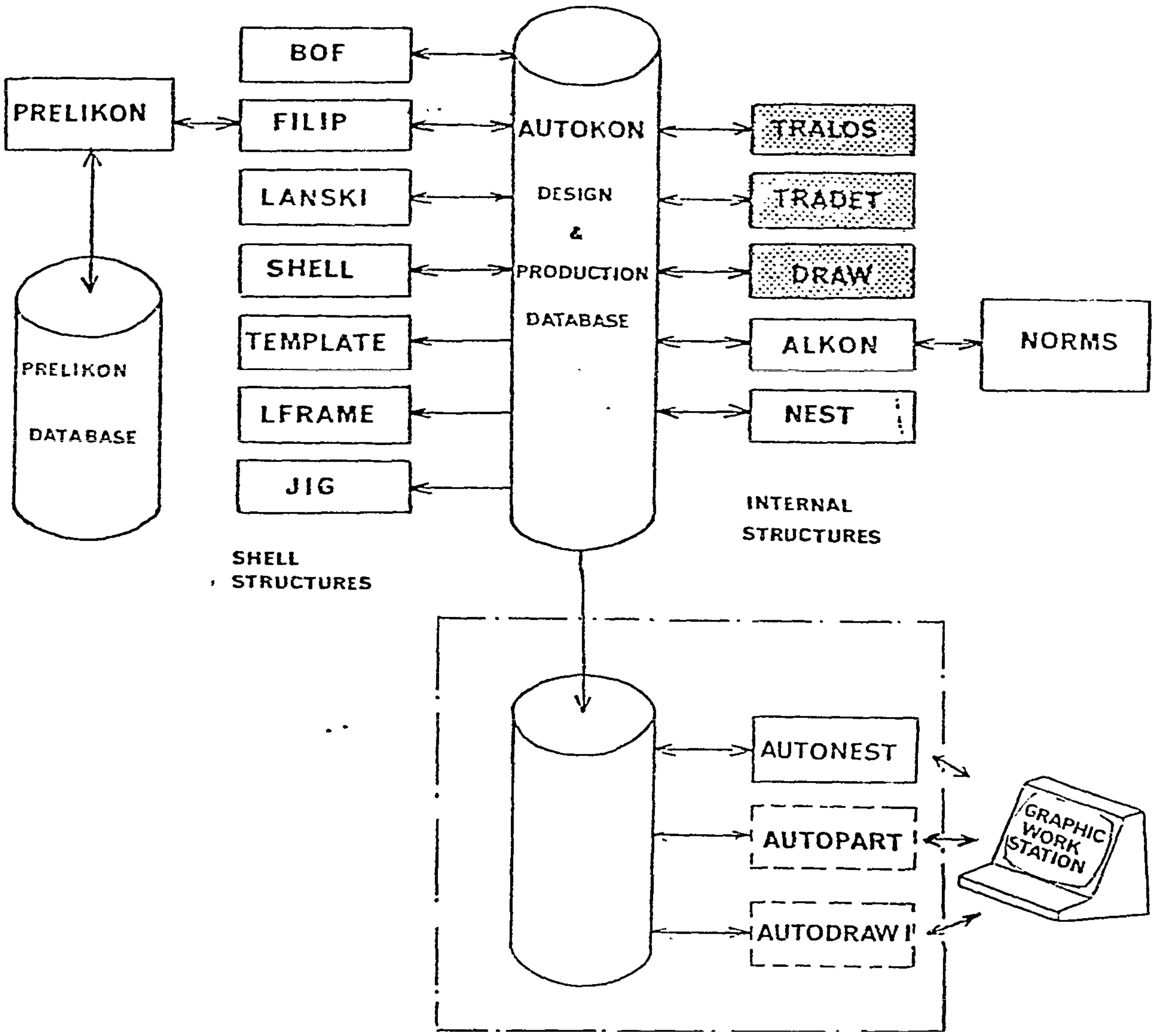


Exhibit 2

AUTOKON-79 and the modules AUTOPART and AUTODRAW.
The three modules AUTOPART, AUTONEST and AUTODRAW are a system for Interactive Generation of Production Information.

AUTONEST

AUTONEST has been in successfull operation for more than 2 years in several yards. It is working on a Norwegian NORD-10 16 bits mini computer as well as on a PRIME P550. A Tektronix 4014/l storage tube with EGM option is used. An attempt to convert AUTONEST to a Tektronix 4081 refresh work station (without using a host computer) has not been quite successfull yet.

The modern high speed transmision long distance network as in Canada has made it interesting to run AUTONEST from remote on a large central computer. We have in our plans to implement it on an UNIVAC 1110 to try out these possibilities.

Experience shows that the average time for a medium complex format is 0,5-1 hour to complete the job.

AUTONEST is an entirely self contained system in the sense that both lay-out (nesting), sequencing and papertape generation is done by AUTONEST itself. See Exhibit 3.

The parts to be nested in the AUTOKON-79 system are generated by ALKON. Alternatively, they will be made interactively by AUTOPART.

The jig-saw puzzle is fully controlled by the user. He may move rotate and mirror image a part in any manner he wants. In case of overlapping the system is providing self control, and any point of the screen may be blown up in full scale for detailed checking if necessary.

The user may nest a cluster of parts and treat it as one part. This is very usefull in putting pre-nested -details around in a format to utilize scrap, especially interesting in connection with plasma cutting. The high cutting speed allows it without making the cutting machine a bottleneck as often is the case in conventional oxy-cutting.

The sequencing is done interactively in a very straight forward way. A little light point is following the predefined marking and part coding sequence. This point is stopped by the user at places where bridges are desired. He is completely free to chose sequence, and auxilliary functions may be freely manipulated at this stage.

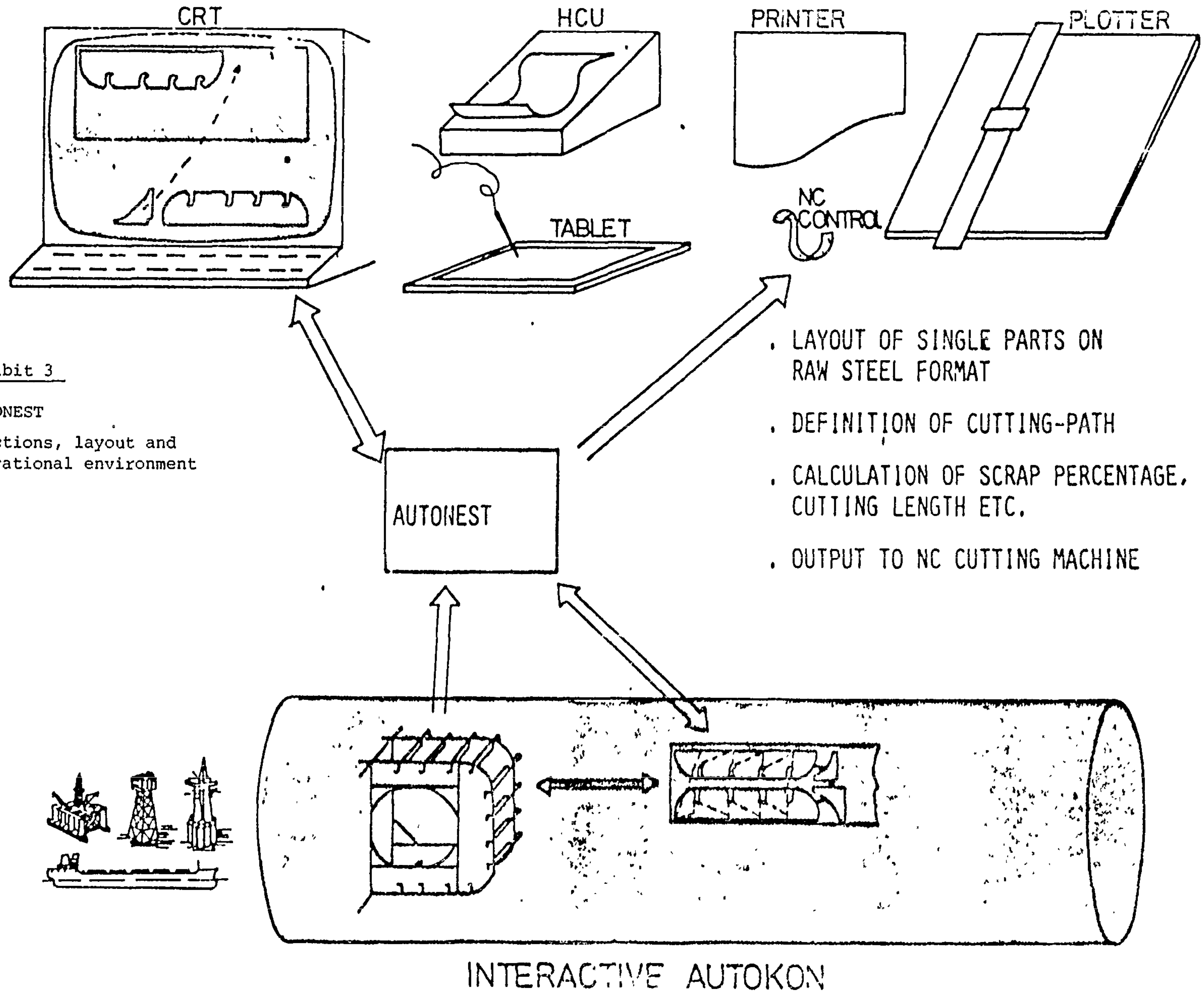


Exhibit 3

AUTONEST

Functions, layout and operational environment

AUTOPART

By means of AUTOPART, the user may

define parts "from scratch" as a sequence of basic geometric elements like: straight line, circle, etc, without any reference to predefined information.

define parts, referring to previously defined contours, generated by AUTOPART itself or by AUTOKON-79.

define macros such as cut outs, holes etc. and use them any where in the part definition.

modify parts previously defined by AUTOPART

split parts in smaller parts. (under develop).

define "drawing" symbols for manipulation by AUTODRAW.

See Exhibit 4 for layout and functions.

The "Language" is fairly similar to ALKON. In ALKON, the user writes a manuscript which comprises all statements necessary for generating the whole part in one run. If he has made a mistake, he will not know until he gets the verfication of the "paper-tape". In most batch-processing environments this takes anything from 0.5 hour to 2 hours. Sometime even more.

When the user is coding the same part in AUTOPART he will generate one contour element after the other and immediately see the result of his commands. When an error occurs he can correct it immediately before proceeding. He can follow his coding almost as in the "old days" when he was drawing parts by hand. The total elapsed time of the job is reduced to the effective time the user needs to code the part. We believe he will also work more efficiently than in a batch system.

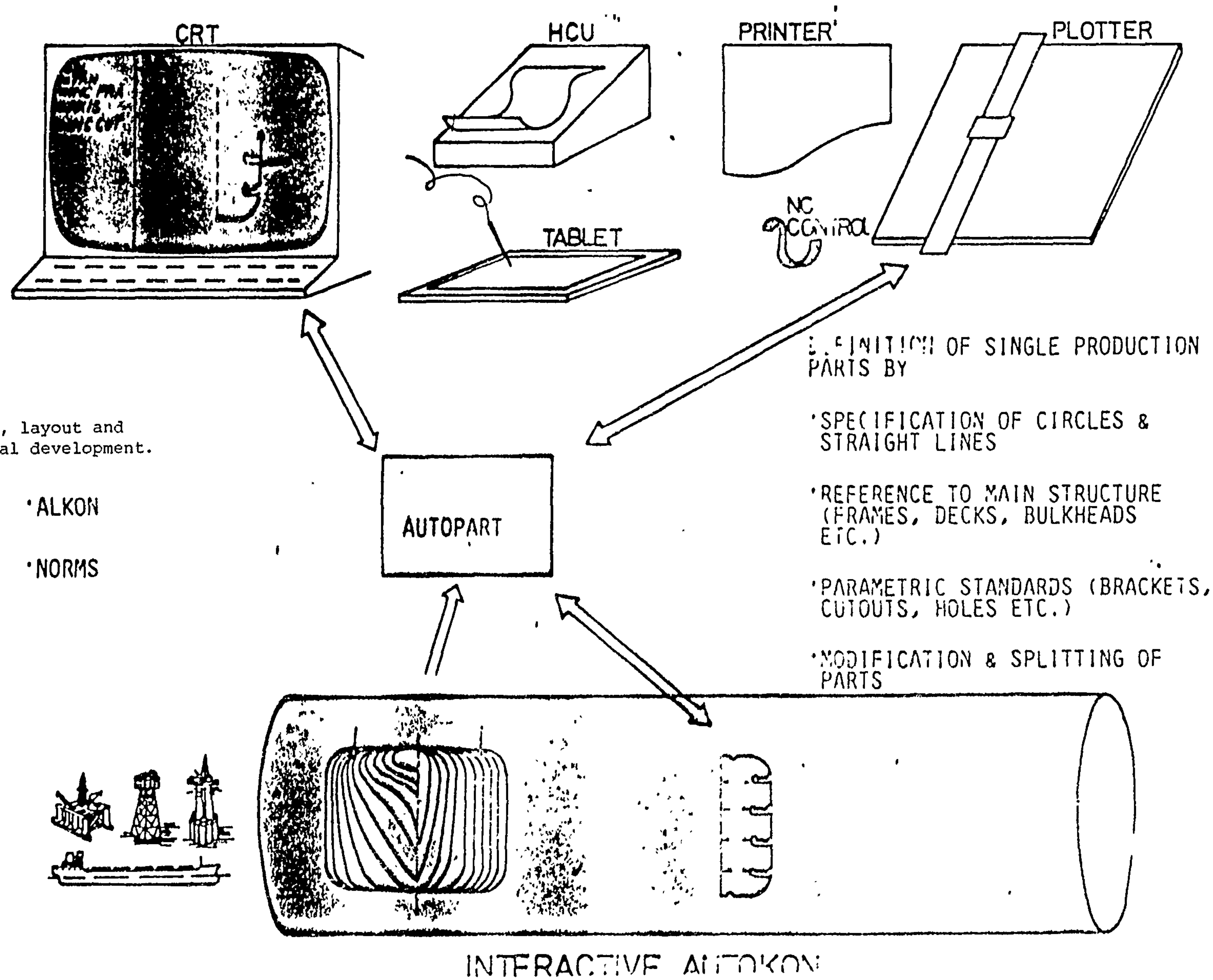
Exhibit 5 shows the part in the final stage of coding. In Exhibit 6,7,8 and 9 the user has asked for control of various data incorporated in the final part description.

The old ALKON user will probably ask: Do we need both ALKON and AUTOPART?

Exhibit 4

AUTOPART.

Functions, layout and operational development.



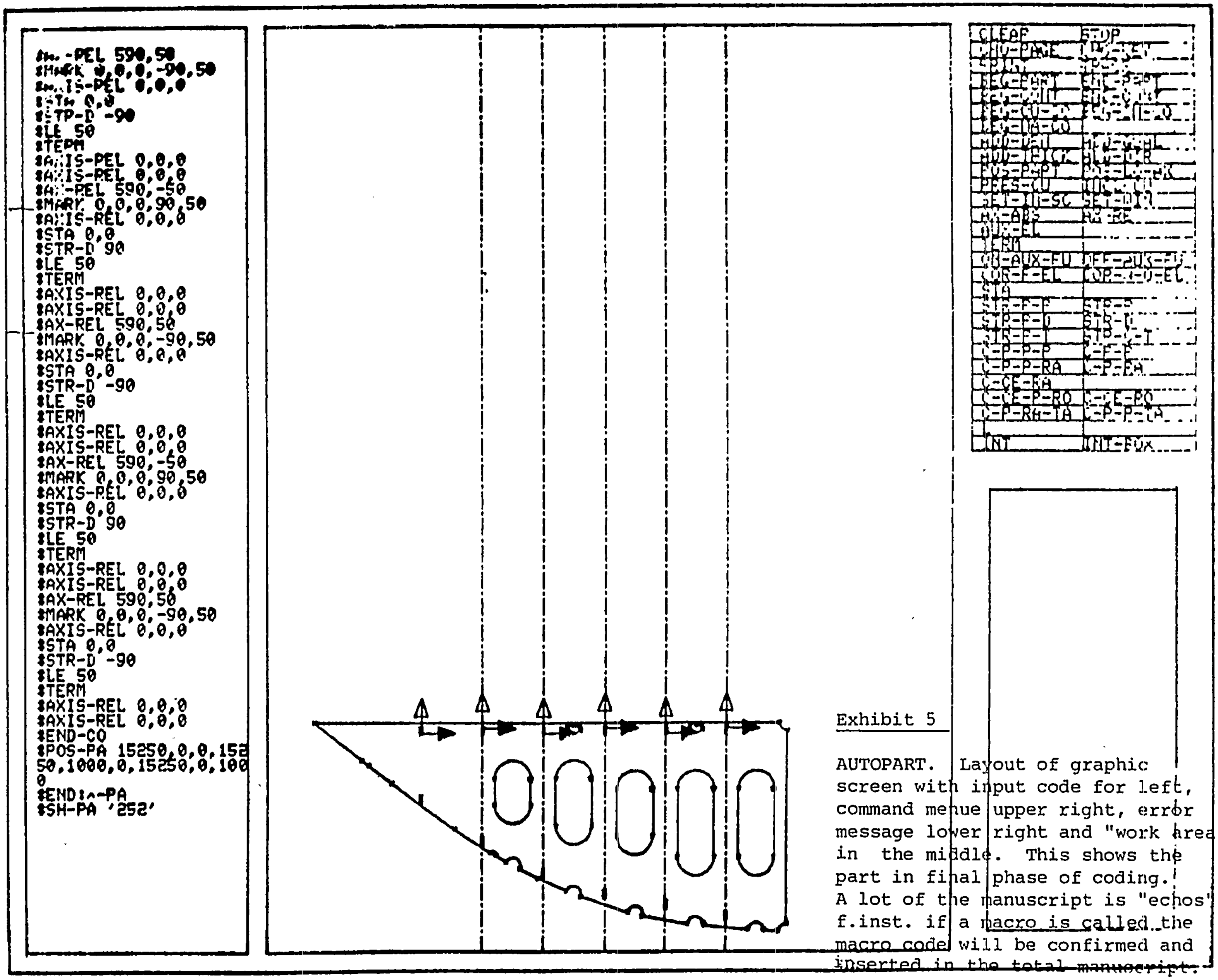


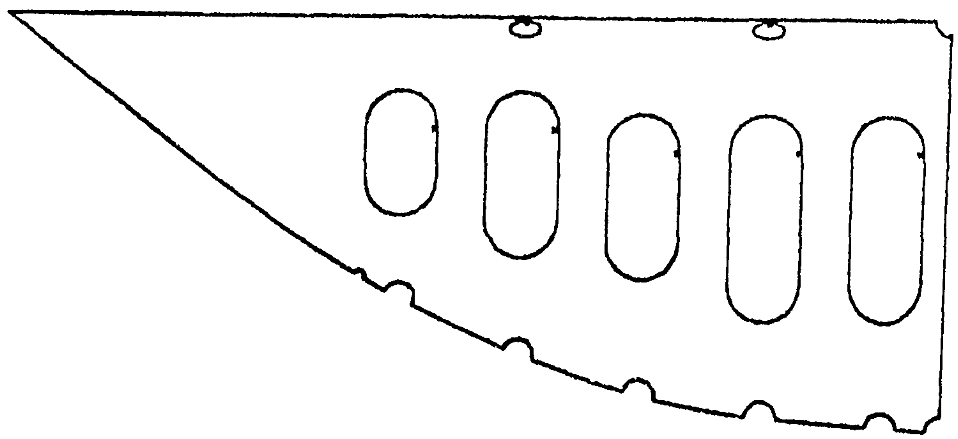
Exhibit 5

AUTOPART. Layout of graphic screen with input code for left, command menue upper right, error message lower right and "work area" in the middle. This shows the part in final phase of coding. A lot of the manuscript is "echos", f.inst. if a macro is called the macro code will be confirmed and inserted in the total manuscript.

```
1
STATUS          :
1
GEOM. REC.      :
543
AU.. FUNC.REC.  :
550       0
TEXT REC.       :
0
REF. POINT      :
-1610.00   1419.00
CONT. NO.       :
5     1       0
0
CONT. TYPE      :
102
ICTYPE          :
1
STATUS          :
1
GEOM. REC.      :
543
AUX. FUNC.REC.  :
544       0
TEXT REC.       :
0
REF. POINT      :
-1475.00   1969.00
*CLEAR
```

Exhibit 6

AUTOPART. Control view of external countour and holes of the finished part. Most of the text is control output.



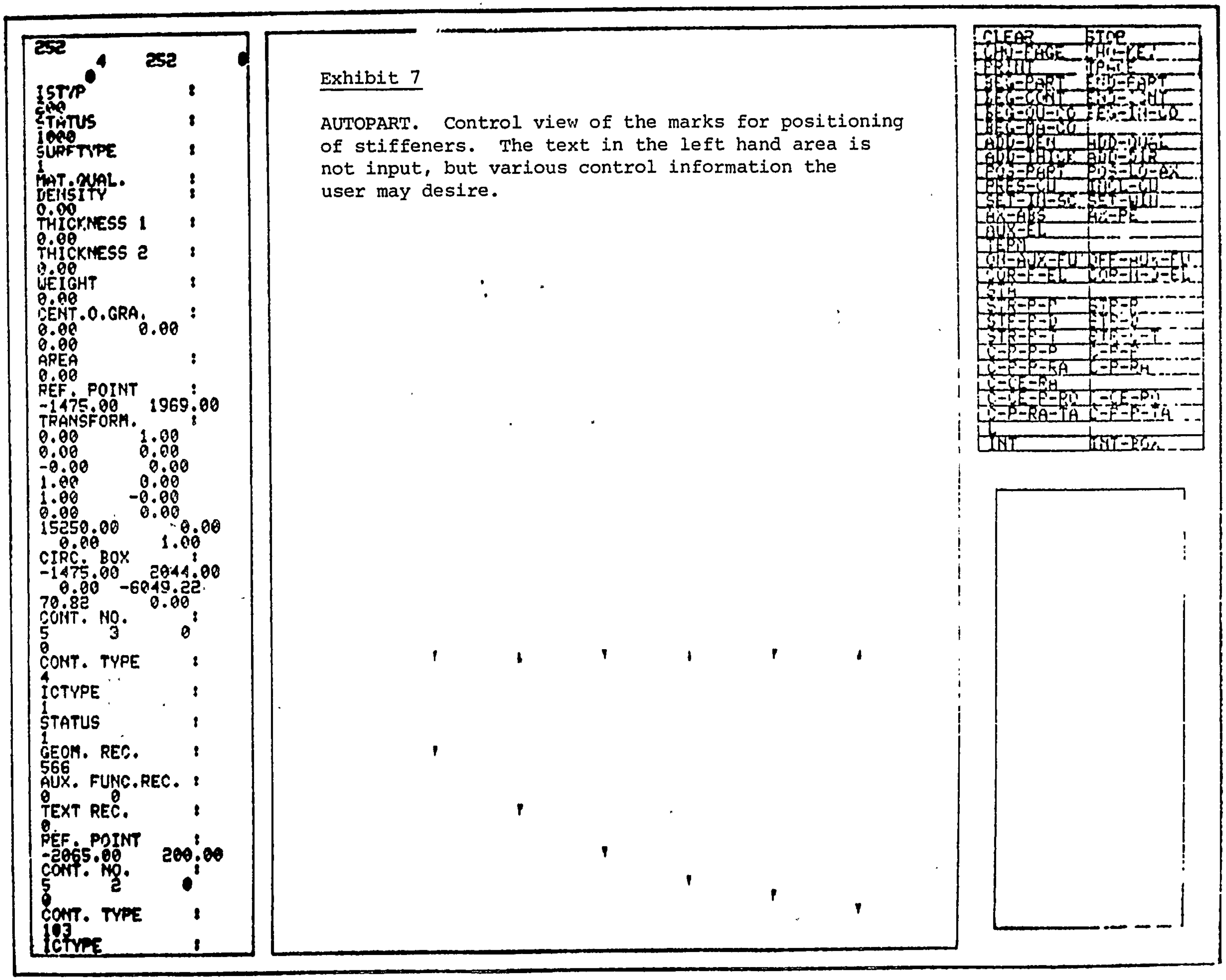


Exhibit 7

AUTOPART. Control view of the marks for positioning of stiffeners. The text in the left hand area is not input, but various control information the user may desire.

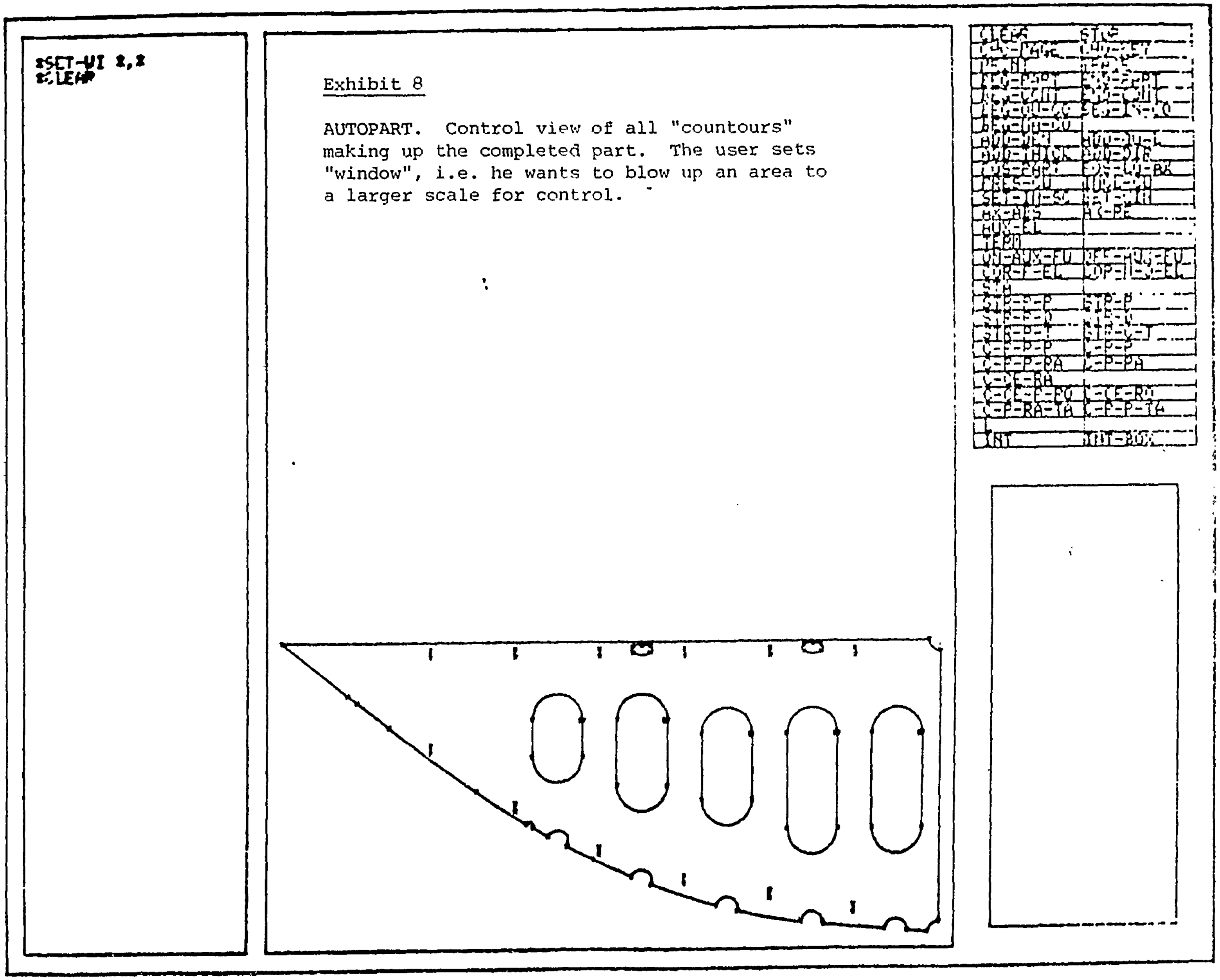


Exhibit 8

AUTOPART. Control view of all "countours" making up the completed part. The user sets "window", i.e. he wants to blow up an area to a larger scale for control.

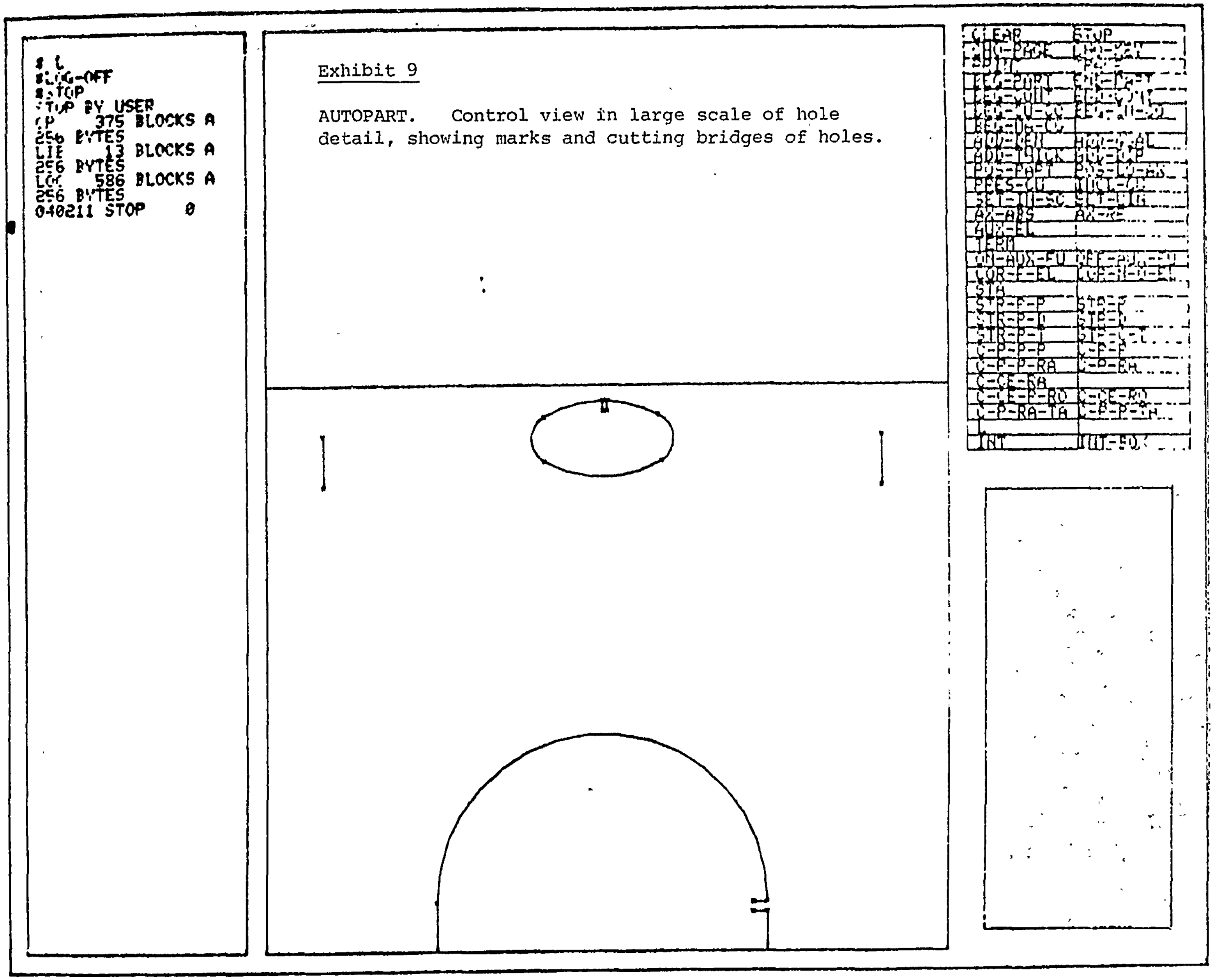


Exhibit 9

AUTOPART. Control view in large scale of hole detail, showing marks and cutting bridges of holes.

will be

The answer depends on what we are going to do. AUTOPART is sufficent to do lofting on a part by part level either from a "scratch" basis or when utilizing all kind of reference contours from AUTOKON-79. But the reference contours themselves are very efficiently generated by the 10 new statements of ALKON. These new statements in their turn get their reference information from the structural model of AUTOKON-79. That means from BOF, LANSKI and TRADET for the shell structure and from TRALOS and TRADET for the internal structure. The BOF/LANSKI data have always been available before partcoding. But imagine the amount of information now available on internal structures, thanks to TRALOS and TRADET. ALKON is also used to make face contours of webframes, stringers, and other "free" contours to complete the TRALOS/TRADET structure for detailing of documentation by the (batch) DRAW module.

The user may define his screen layout, he may easily change from one mode (pointing on screen menue) to another (key boarding the commands). Menues, manuscripts, an error messages are in separate areas and do not mess up the geometry "work area".

AUTODRAW

AUTODRAW is an interactive graphics system and should be distinguished from the AUTOKON-79 module DRAW. See <u>Exhibit 10</u> for layout and main functions.

Even if AUTOKON-79 can generate quite a variety of layout and block drawings, they are only predefined views and contain allmost nothing but geometrical information. By a thumb rule, we may classify them as only 2/3 complete. Therefore, quite a lot of efforts are needed to "shine up" and complete them. By dimensions, scantlings, material codes, reference to and drawing of details, job instructions, and whatever other "text" considered necessary to make the drawing serve as an information carrier for parties concerned. All these information is not very easily dealt with by batch programs. But the interactive graphics technology is excellent for this purpose.

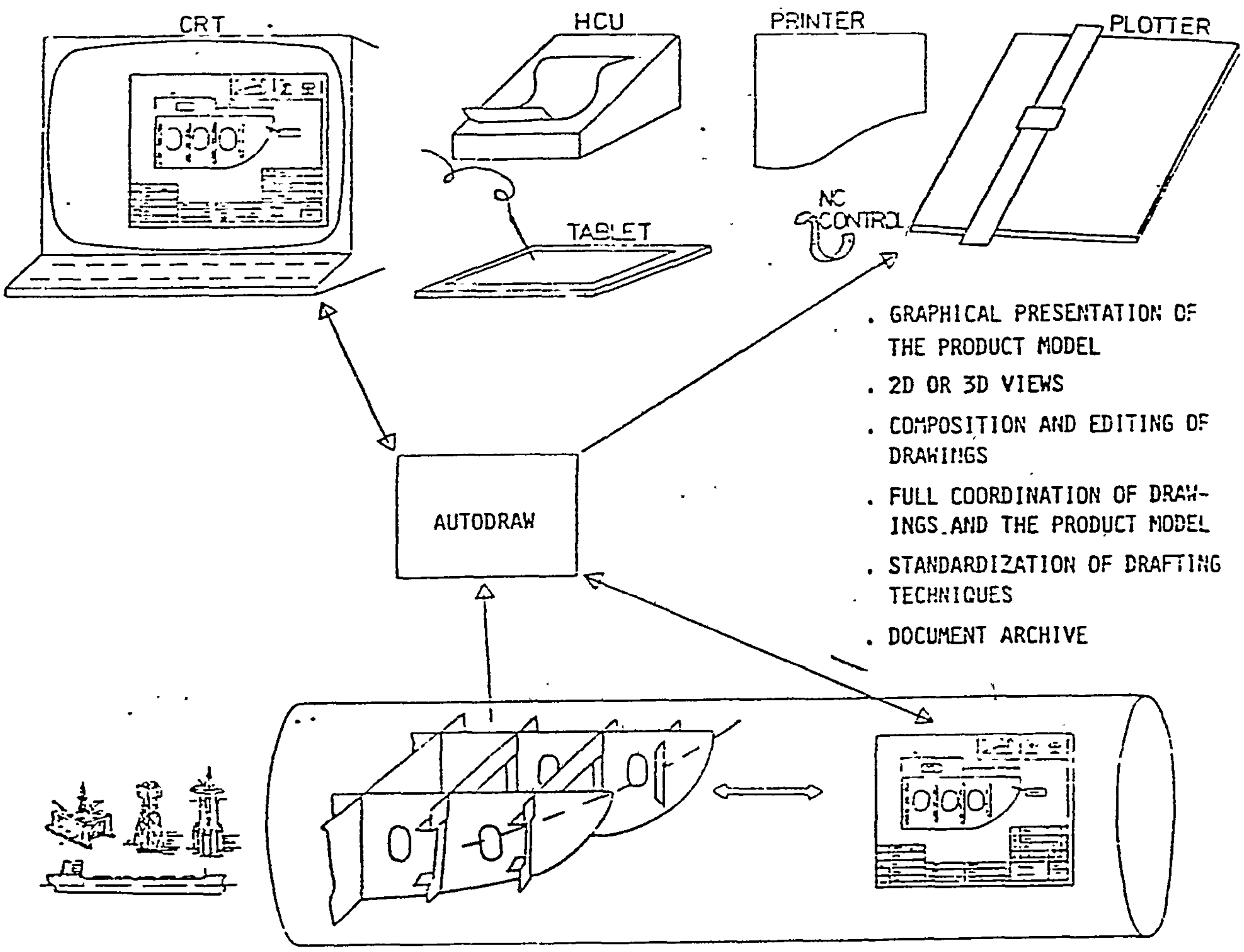
The main purpose of AUTODRAW is to manipulate <u>predefined</u> geometry, from AUTOKON-79, from AUTOPART or in the future, from the new AUTOKON "interactive steel design" system. More specifically the function of AUTODRAW will include:

1. <u>Verfication</u>

   of contours, tables, text

Exhibit 10

AUTODRAW, its functions and operational environment.



2. <u>Generation of drawings</u>

a) Compostion or lay-out

b) Completion by:
- text
- symbols
- dimension lines
- indentification, reference
- "drawing techniques" - "cosmetic" treatment

c) Generate other views:

- orthogonal
- perspective
- axinometric/iSometric

3. Build and administrate document library

- Storing, retrieval, distribution

Most of functions under 1) and 2) are operating in a pilot stage. But generally AUTODRAW is 'still under development.

In addition to above functions, AUTODRAW may be used in the same way as a graphics turn key system, as a "drafting" tool to make "pictures" on the screen. As far as structures are concerned, this function is a minor one. We do not need it so much, since the whole idea with AUTOKON is establish a computer based "product model" and manipulate it. A drawing is basically an extract of the "structural model" information presented on a piece of paper in some desired view and scale and completed with additional information to make this document complete.

Example

The various parts of a double bottom structure have been made by AUTOPART and stored in their proper position and orientation within the structure.

By means of AUTODRAW the user may ask for the whole structure and compose a drawing with orthogonal views. (Exhibit 11). when making the composit, he may either move around single data, or he may define a certain collection of information as a "segment" which he may move as a whole by using the cursor. (Exhibit 12). If he wants a perspective, he will get it. (Exhibit 13). This shows the potential of having a very flexible documentation technique using one single source of information, the "product model".

The problem of removing hidden lines is under solution in a methods development, see Exhibit 14. A more shipbuilding type example of this problem appears from Exhibit 15, where a part is seen through a hole of another part.

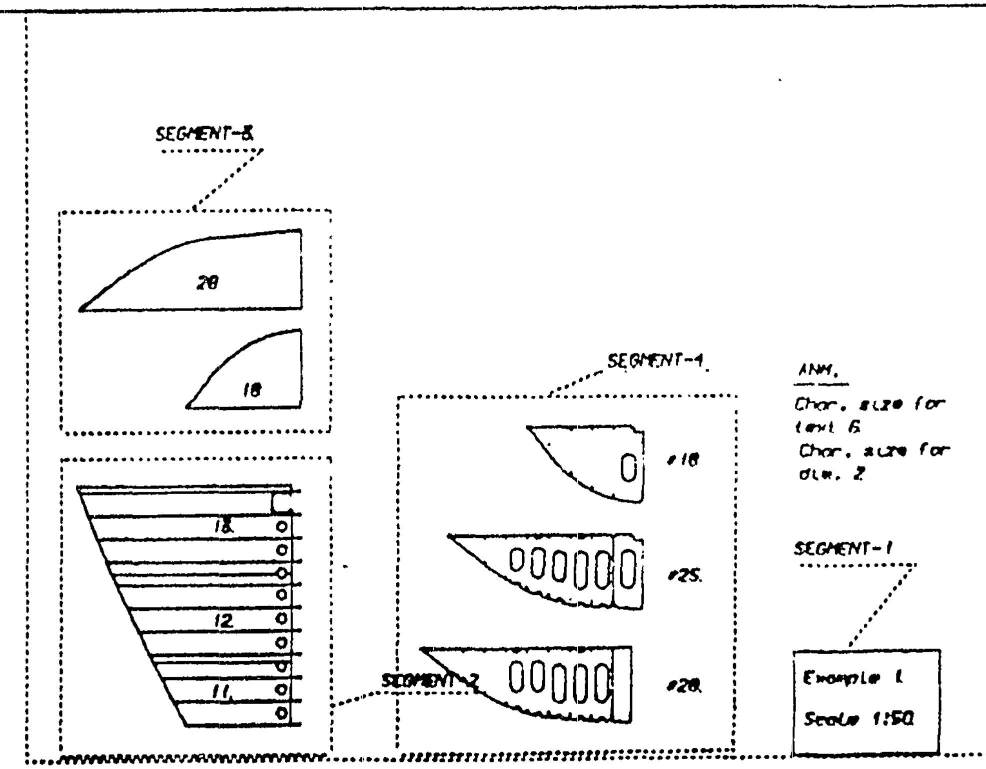
Since all contours reflect predefined objects, any dimension from any point to another may be derived by pointing with the cursor on the respective points. The dimension will be displayed and the user may locate it with proper "dimension lines" by using the cursor. (Exhibit 16).

Text may be generated in any size, shear, and line angle. The user simply operates the Tektronix key board as a "typewriter" together with the cursor. Exhibit 17 has been "written" by AUTODRAW. All text is included when later asking the plotter to generate the drawing on paper.

Exhibit 11

AUTODRAW

Orthogonal views of a double bottom structures. The drawing is made on basis of parts generated and stored by AUTOPART.



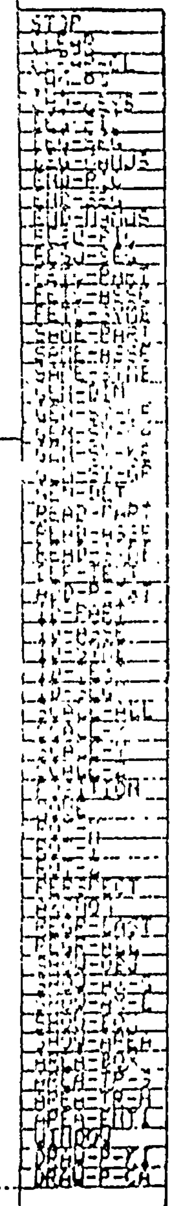
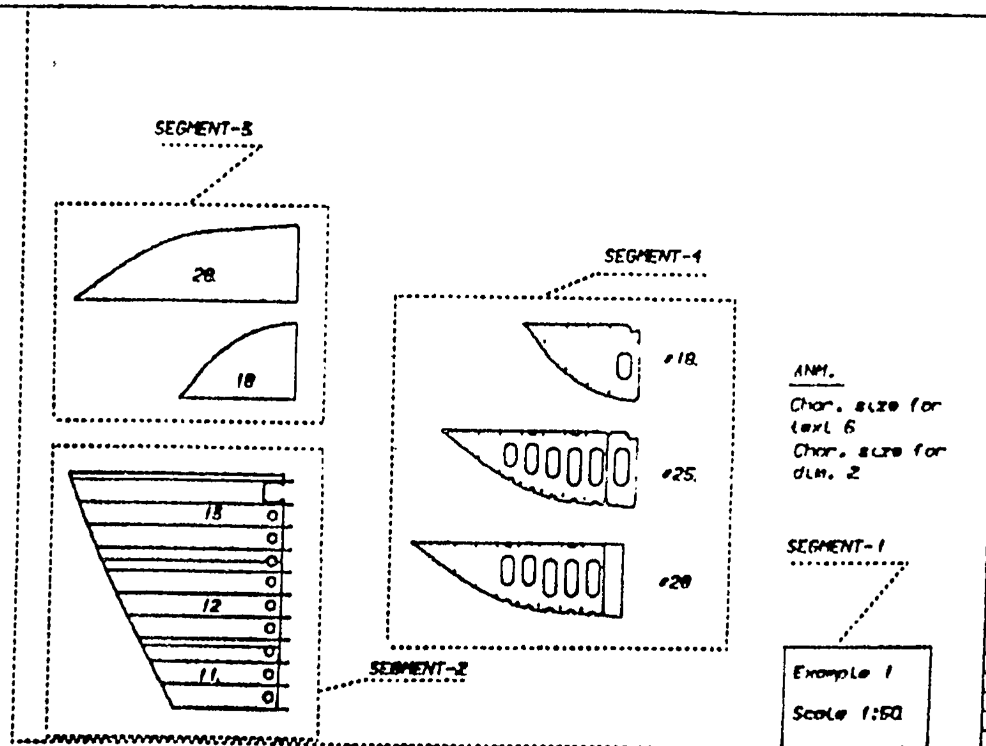
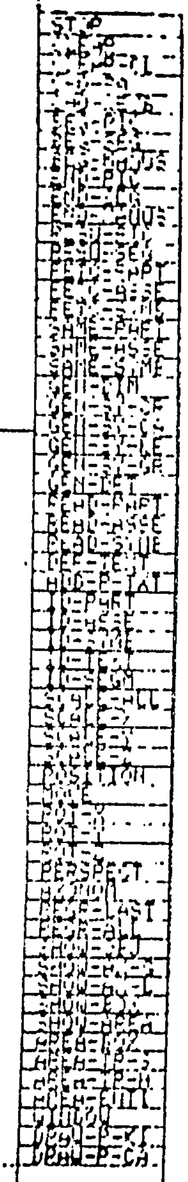


Exhibit 12

AUTODRAW

The user has asked the system to change the lay-out of this drawing by moving a group of information (segment 4) as compared to exhibit 11.



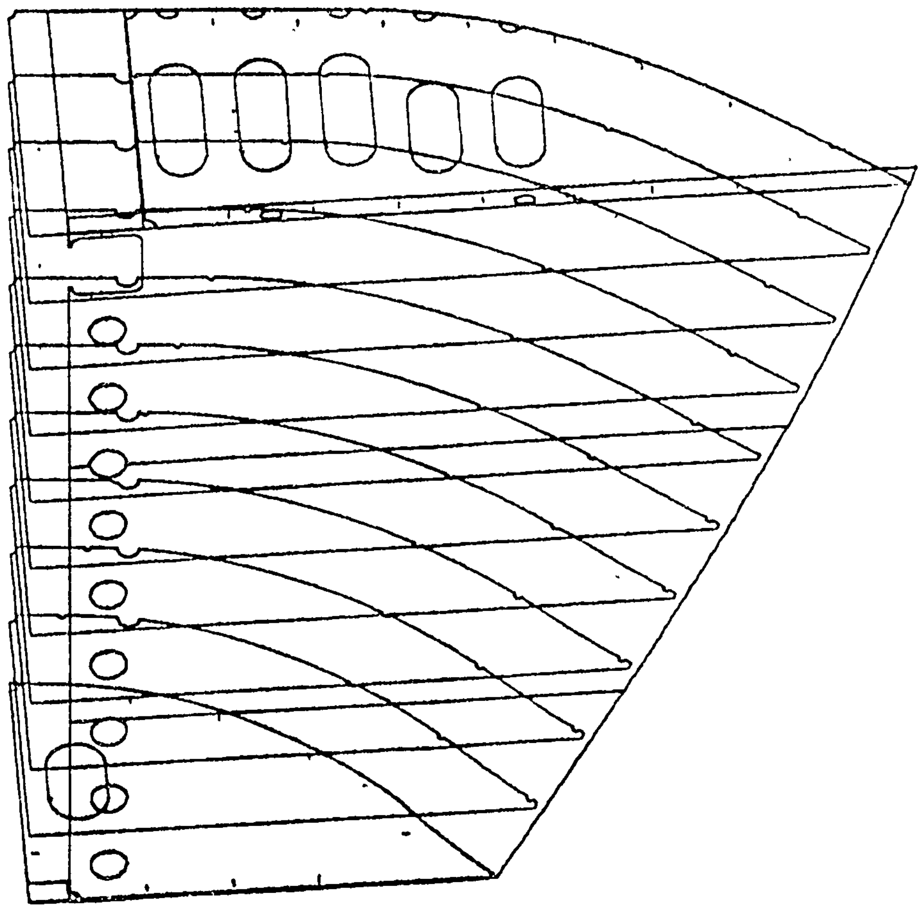


```
$END-SEG
$[illegible]SU-SEG SEGMENT-2
$[illegible]-PA '18'
$[illegible]-[illegible]EJ
$[illegible]E-PA '181'
$[illegible]-PA '28'
$S4-[illegible]BJ
$[illegible]E-PA '281'
$[illegible]ATE-PA '282'
$END-SEG
```

Exhibit 13

AUTODRAW

The same information as before, presented in a perspective view.



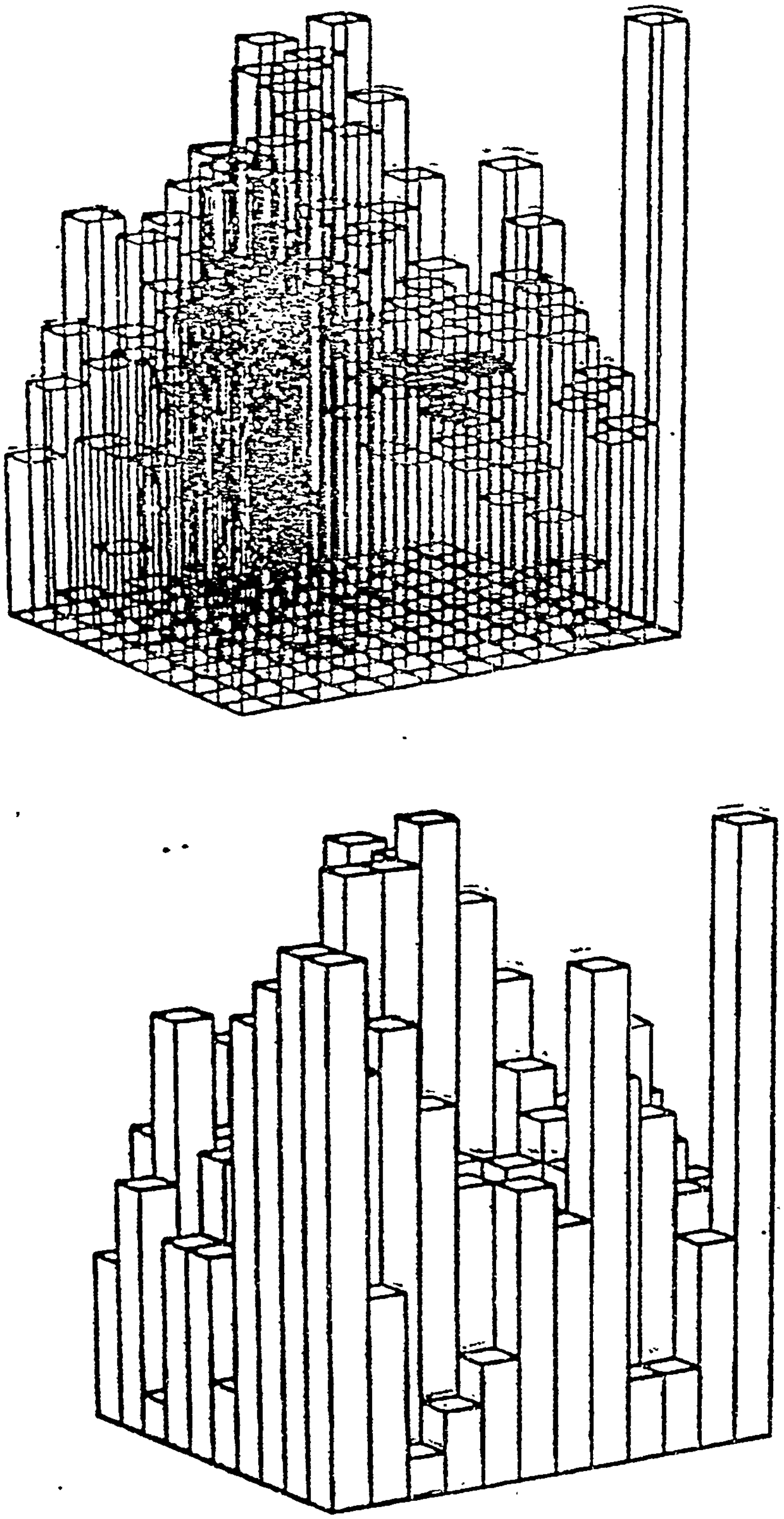


Exhibit 14

Example showing removal of hidden lines. Results from a methods development project, supporting the AUTODRAW development.

Exhibit 15

Removal of hidden lines. Results from a methods development project, supporting the AUTODRAW development.

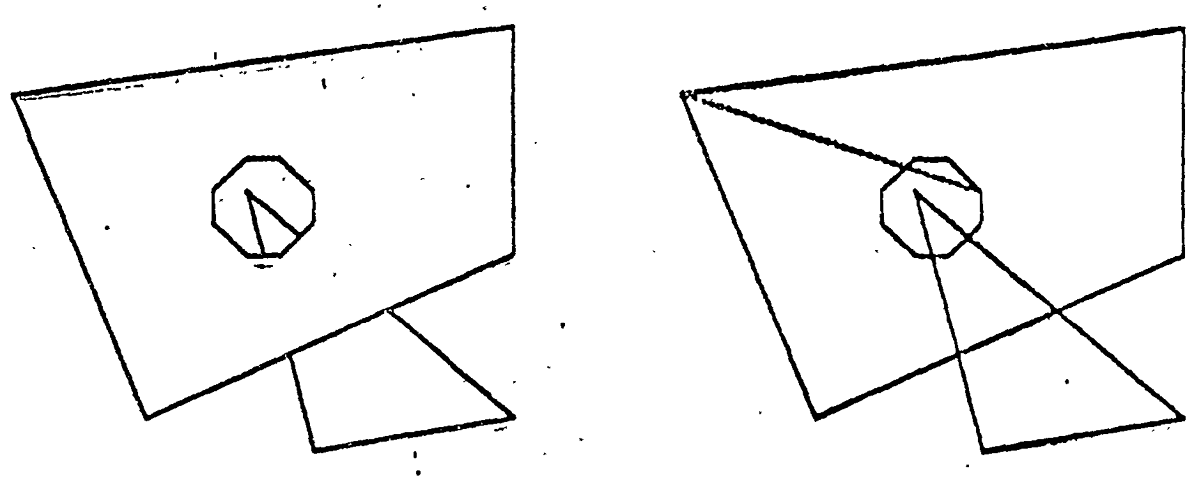


Exhibit 16

AUTODRAW

Automatic "dimensioning" of a tank top, obtained by 'the user by pointing with the cursor on the desired locations.

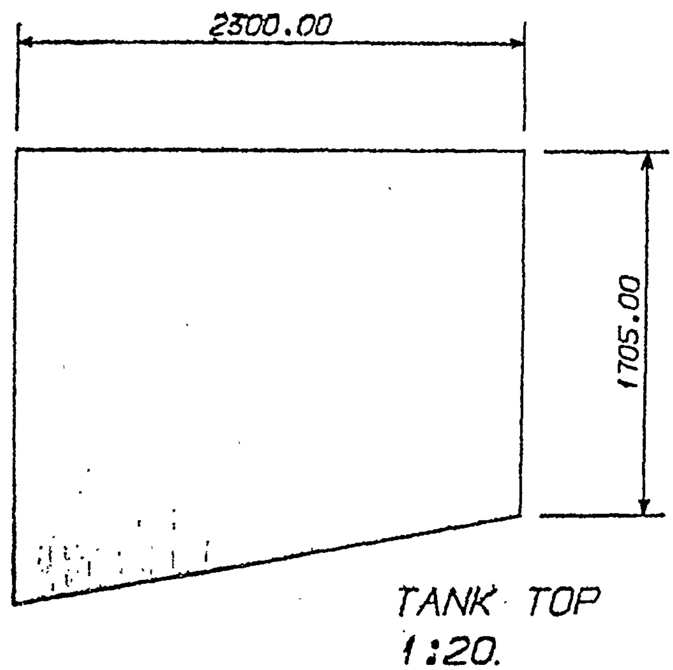


Exhibit 17

AUTODRAW

Hard copy with output from "texting" the facilities.

AUTODRAW

FUNCTIONS TODAY:

fetch predefined objects
generote objects by simple drawing functions
fetch predefined text
generate text (any size, shear, and line angle)
all 2D and 3D transformations (incl. perspective)
dimensioning (automatic computation)
work area selection
def of "picture segments"
window specification-

FUNCTIONS 1979/1980:

- *automatic detail generation*
- *remove hidden lines*
- *symbol menues*
- *drawing Library*

Exhibits 18 to 20 show an example using AUTODRAW in connection with an accommodation drawing. In this case the furniture have been defined by AUTOPART. Parts are not necessarily made of steel plates. By thinking in terms of "geometry" rather than in steel structure, it is obvious that imagination may make these modules usefull for many purposes.

AUTOPART and AUTODRAW are tightly connected. In fact, they may be regarded as a "tool kit" in which the user may easily switch from one tool to another. It means that any modification by AUTOPART will automatically update the drawing containing that part. It will also make a modification on the drawing that will lead to an update of the "product model". This link is under development.

In the overall AUTOKON context the practical implications of AUTODRAW are as follows:

Flexible work shop drawings

AUTOKON may be used to generate shop drawings which fit the principle "one job-one drawing". In other words, a hierarchy of shop drawings, that reflects the hierarchy of block, subassemblies, sub-sub assemblies, etc. down to parts. The "product model" contain the structure. The mentioned hierarchy of drawings is just another way of making work shop documentation than the tradional block drawing. In the latter all information are in one document.

Alternatively, assemblies may be shown in isometric or perspective views for clarification or as control drawings.

It is quite interesting to note that the above shop drawings are made from parts information, not as by tradition, the other way around.

Design drawings

Basically, design drawings may be regarded as high level "assembly" drawings, hence they may be generated as described above.

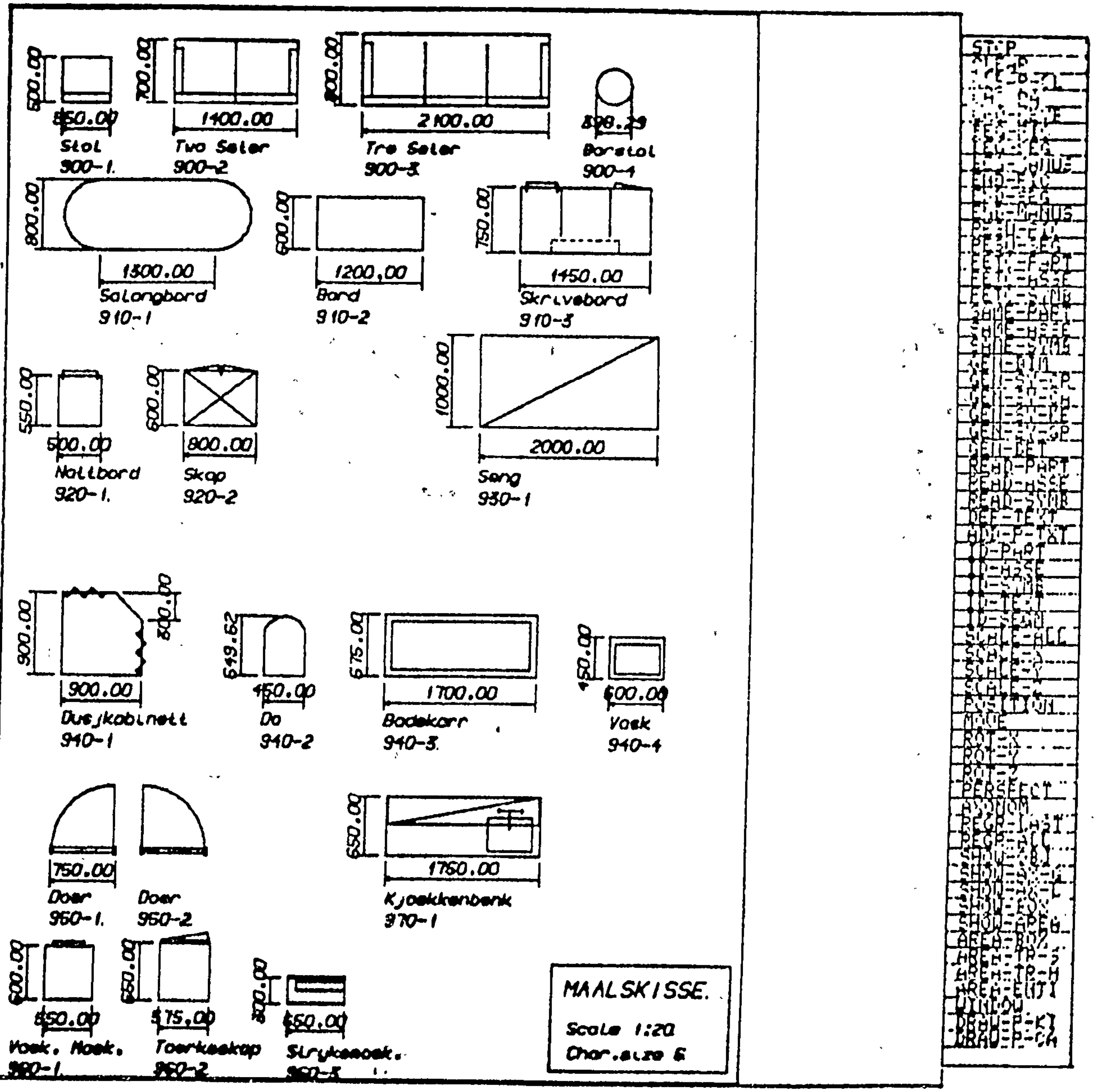
However, the whole idea of AUTOKON-79 is to generate various kind of design drawings at the earliest possible stage, where there are no parts. Therefore, we want to utilize the batch generated drawings from AUTOKON-79 as a departure point for further "treatment" by AUTODRAW.

SEND-PI PICTURE-1
$
MISIG. OPERATOR
$

Exhibit 18

AUTODRAW

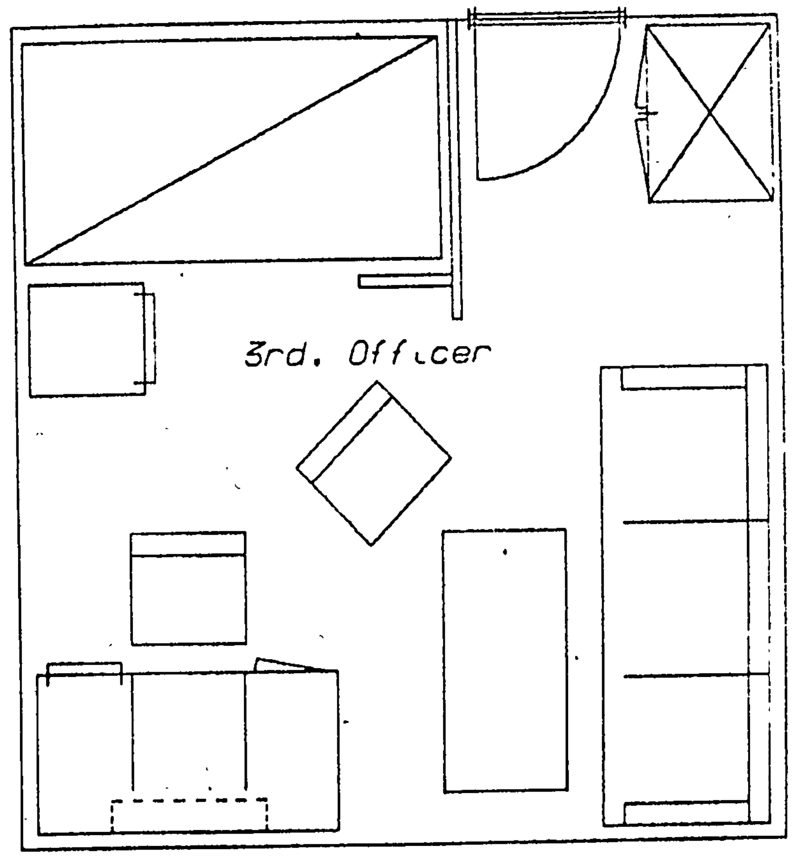
Dealing with accommodation. The furniture are "parts" made by AUTOPART. This exhibit shows a catalogue produced by AUTODRAW.



Ehhibit 19

AUTODRAW

Accommodation plan produced by means of AUTODRAW based on the catalogue parts.
This cabin may be defined as a group of information that can be mirrored, rotated and moved as a whole.



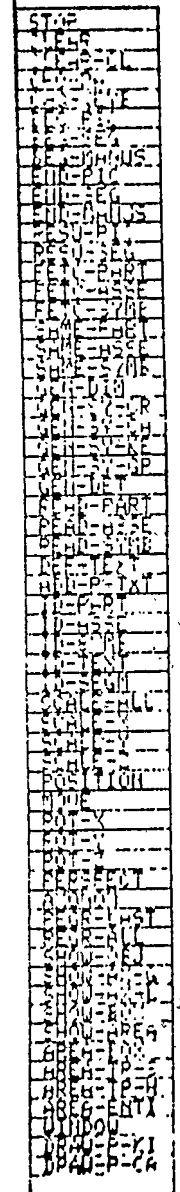
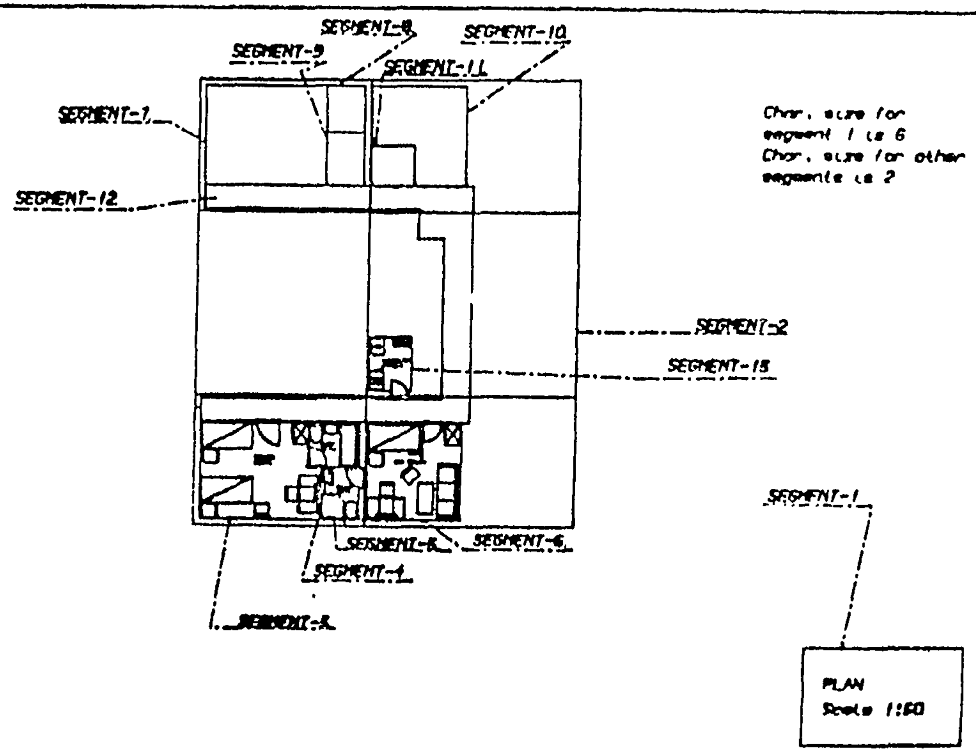


Exhibit 20

AUTODRAW

Building up an accommodation plan. It may either be a result of adding up a number of predefined "modules". Or the "steel bulkheads" defined first and the furniture arranged within the constraints.



We are simply using AUTODRAW as a pencil to complete the document. When making a plot of the completed drawing, the new "paper tape image will be the old one pluss the information we added by using AUTODRAW.

The observant reader will have noticed the difference from the way AUTOPART/AUTODRAW were used to generate drawings. In the first case we were communicating with the production oriented model, in the second with a document that originated from the design model of AUTOKON-79.

CONCLUDING REMARKS

AUTONEST is already a stable system proven in a actual production environment. AUTOPART is in its completion stage within the specifications, and will need some piloting before release. AUTODRAW has still some development ahead to complete the desired functions, which we believe will be satisfactorily covered. Our main concern is to search for better ways to implement AUTODRAW to improve efficiency and response time. The latter is quite crucial in order to have full user accept. We are quite confident we will find the remedies. It should be stressed once more, that even if AUTODRAW may be used for general drafting, its major objective is to manupulate predefined information. AUTOPART, AUTONEST and AUTODRAW will have its strength in their integration, first of all as an "auxilliary" and part of total AUTOKON. 'But also as a stand alone system for basically 2-D problems.

APPLICATION OF THE GIFTS-5 MINIBASED GRAPHICS SYSTEM FOR SHIP DESIGN AND ANALYSIS

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Professor of Aerospace and Mechanical Engineering
University of Arizona
Tucson, Arizona

Dr. Kamel is Professor of Aerospace and Mechanical Engineering, and is also currently serving as Director of the Interactive Graphics Engineering Laboratory while conducting research in the areas of finite-element methods, computer graphics, engineering software, and numerical analysis.

Dr. Kamel holds degrees from the Imperial College of Science and Technology in London, England and a degree from Cairo University in Egypt. His past positions include Associate Professorship at the University of Arizona, and Research Specialist at Boeing Aircraft Company. He has also served as Senior Lecturer and Head of the Applied Programming Group at the Institut fur Statik and Dynamik der Luft-and Raufahrtkon-struktionem Technische Hochschule, in Stuttgart, Germany.

APPLICATION OF THE GIFTS-5 MINI-BASED GRAPHICS SYSTEM FOR SHIP DESIGN AND ANALYSIS

H.A. Kamel, Professor of Aerospace and Mechanical Engineering,
University of Arizona, Tucson.

INTRODUCTION

The GIFTS finite element structural analysis system has been developed with the support of the Office of Naval Research, the U.S. Coast Guard, and members of the GIFTS Users Group (GUG). It is a graphics-oriented collection of programs, which operate on a standardized data base. The system is designed to fit in a relatively small core area, and is specifically suited to time sharing and mini-computer systems. It may be used as a stand-alone finite element package or as a pre- and postprocessor for other systems.

CAPABILITIES OF GIFTS 5

A. Model Generation. Automatic model generation and interactive model editor. Generation of parametric lines with equally, or unequally spaced points, generation of three- and four-sided surface patches, covered with triangular or quadrilateral elements of arbitrary order. Generation of line structural elements of arbitrary order, including a sophisticated library of beam elements. Generation of six-sided and five-sided solid regions, filled with first order solid elements.

B. Model Display. Display of model outlines or detailed element plots. Choice of absolute viewing direction or incremental rotations. Labelling by user of system point number, element number, element type, material or thickness number. Introduction of perspective. Selected display by boxing parallel to model or display axes. Selective elimination of surface patches. Selective plotting of point or element slices in solid regions.

C. Generation and Display of Load and Boundary Conditions. GIFTS is capable of load and boundary condition generation on surface patches, lines or points, as well as inertial loading due to translational acceleration or angular velocity. The user may obtain plots of loads and moments applied to the model, in the form of arrows, whose scale may be influenced by the user. The model freedoms may be displayed in the form of vectors, superimposed on the model. Prescribed displacements and freedom-to-freedom constraints may be introduced by the use of Lagrange constraints.

D. Displacement and Stress Display. A plot of the deformed model, with automatically scaled displacement, may be produced once the deflections have been computed. All model plotting options are applicable. In addition, the user may change the displacement scale, or create composite loading cases by linearly combining a number of loading cases. Labelled stress contours may be plotted within the area being viewed. Principal stresses may be displayed as vectors showing direction and magnitude. Symbols denoting stress level may also be used. For beam elements applied forces and resultant shear and moments diagrams over the length of the beam element are displayed. A detailed plot showing normal stress and shear stress distributions over the cross-section may be produced at any point along the beam's length.

E. Static Analysis. The GIFTS 5 analysis package supports a library of basic first order elements encompassing a rod element, a general purpose beam element, triangular and quadrilateral membrane elements, triangular and quadrilateral axisymmetric elements, triangular and quadrilateral bending elements and constrained substructures as well as second order rod, triangular and quadrilateral membrane and triangular and quadrilateral axisymmetric elements. Matrix partitioning is utilized to set up and solve the equations. Several nodes are lumped together in each partition to increase solution efficiency. A band- width optimization program is included, although the program is not band width limited.

F. Substructuring. The program has substructuring and constrained substructuring capabilities. The substructure boundaries may be kinematically constrained using rigid linear or cubic constraint functions.. Substructures and/or constrained substructures may be assembled, together with ordinary finite elements to form a model. After model analysis,- it is possible to request a local analysis of any individual substructure.

G. Vibrational Mode Analysis. GIFTS 5 uses the subspace iteration method to obtain a number of the lowest vibrational frequencies and modes of an arbitrary structure. Stresses may also be computed.

H. Transient Response Analysis. It is possible to apply a time varying load to a structure, and compute the deflection and stress histories. GIFTS uses the Houbolt scheme (third order backward difference).

I. Axisymmetric Solids. GIFTS 5 is capable of solving axisymmetric models under either axisymmetric loads, or non-axisymmetric loads broken down into a Fourier series.

J. Thermal Stress. A temperature field may be defined for any structure being, analyzed, and GIFTS 5 will compute the resulting thermal stresses. It does not, however, have heat flow analysis capability.

K. Retrieval of Numerical Information. Apart from graphic display, GIFTS may be used to extract practically any subset of information from the data base and print it in an organized manner on the screen, or on a line printer.

L. Error Detection. Extensive checks are performed throughout the system to protect the user against his own mistakes. User oriented error and warning messages are printed out wherever appropriate.

MACHINE INDEPENDENCE

GIFTS 5 is written exclusively in FORTRAN IV. A computer word length of 16 bits or more is assumed. No more than four alphanumeric characters are stored in one word. Hollerith constants appear only in DATA statements. All real variables are single precision and no complex variables are used. Disk

files are either sequential or index sequential. In an index sequential file it is assumed that any record may be read or written at random. Most files are blocked for I/O efficiency. Core buffers may contain more than one block. Plotting commands to the terminal are "graphics primitives," and can be easily interfaced to any existing graphics package or, better still, implemented directly. GIFTS-5 includes its own special purpose FORTRAN written Tektronix terminal driver. GIFTS-5 versions are available for the Data General ECLIPSE-S/230, the DEC-10 and DEC-20, the PDP-11 and the PRIME family of comupters. Versions are under preparation for the CDC 6000 series, the IBM-370 series, UNIVAC and VAX-11/780 computers.

DOCUMENTATION

The program/listings contain extensive commenting, which makes GIFTS 5 essentially self-documenting. In addition, however, the following manuals are available:

GIFTS PRIMER -- Contains an introduction to the finite element method and the GIFTS system. The text is illustrated by a number of solved simple examples.

USER'S REFERENCE MANUAL -- A document describing the program operation, instruction set, conventions used and so on.

THEORETICAL MANUAL -- Contains element formulation, and a description of all numerical procedures used in the various solution modules.

SYSTEMS MANUAL -- Contains a detailed description of the Unified Data Base, and key information to the system design.

MODELLING GUIDE -- A discussion of modelling efficiency, supported by many examples and comparison with classical solutions.

INTERFACING GIFTS TO OTHER PROGRAMS

It is a relatively easy task to interface GIFTS to any other finite element programs. After the pre-processing is complete, a program has to be written to extract the relevant data from the GIFTS data base, create an input file for the FEM program, and initiate its execution. It is assumed that the program will place results on an output tape. This output tape can then be read by another interface program, which then feeds the data back into the GIFTS Data Base for further processing and display. Interfaces exist for SAP-IV and ANSYS. Others are being prepared for NASTRAN, STAGS, DAISY and SAP-V.

DISTRIBUTION OF GIFTS 5

GIFTS 5 has been supported by the Office of Naval Research and the United States Coast Guard. It is in the public domain and may be obtained from the University of Arizona for a reasonable charge. Users Groups exist both in the United States (UGUG) and in Europe (EGUG).

POTENTIAL IN SHIP ANALYSIS AND DESIGN

Although the program is being applied regularly to practical ship structure analysis by many organizations, it is somewhat difficult to produce realistic examples of its use in a university environment. Nevertheless, a set of examples are included, which clearly demonstrate the suitability of the program for typical ship structure analysis efforts. These examples span the spectrum from simple beam idealization of a complete tanker hull, to a detailed analysis of a full ship using substructures.

Analysis of a Stiffened Bulkhead.

Figure 1 shows a three-dimensional view of one half of a vertically stiffened bulkhead of, say, an oil tanker. Only one half is modeled because of symmetry. The problem was generated and solved using GIFTS-5 on an ECLIPSE-S/230 minicomputer, running in a time-sharing mode. The model has a total of 195 nodes and 322 elements, 154 of which are beam stiffeners and 168 quadrilateral shell elements. The problem has a total of 839 active degrees of freedom, with a maximum half band width of 106, and a computational (r.m.s) half band width of 76.

Figure 2 shows the commands necessary to generate the model, and apply boundary conditions and loads to it. These commands may be entered either interactively or via a file. The loads produced by the second set of commands are displayed in figure 3, and represent hydrostatic pressures from a partially filled center tank, and a full wing tank. The translational degrees of freedom, showing both symmetry conditions and support from the deck, bottom, side-shell and longitudenal bulkhead appears in figure 4.

The deflections of the bulkhead are shown in figure 5. Stress contours are displayed in figure 6. Load, shear force bending moment and torque diagrams can be displayed for any stiffener element (see figure 7), and detailed stress distribution at any position along the element may be shown (see figure 8).

The analysis, on the time shared minicomputer, cost approximately 40 dollars, based on a standard charging algorithm. The computer time requirements are given below:

Stiffness computation	608	CPU seconds
Decomposition	394	CPU seconds
Deflection computation	101	CPU seconds
Stress computation	62	CPU seconds

Total residence time 41 minutes wall clock time (other jobs running simultaneousely)

Two Dimensional Membrane Analysis of Webframe.

Figure 9 shows the subdivision of a webframe structure into grids, in preparation for the mesh generation procedure. Figure 10 gives the resulting stress contours. Such an analysis is typical of day to day applications. The mesn generator provides a basic arrangement of nodes and elements, which may be then editted using the GIFTS editting module, to introduce local changes, such as stiffeners.

Analysis of an Idealized Bulk Carrier Using Substructuring.

This analysis was conducted as a term project by two students at the university. A typical bay of the ship was modeled using substructures, each involving up to 700 degrees of freedom, see figure 11. These substructures are then repeated over the parallel midside portion of the ship, and the fore and aft portions were completed using ordinary shell finite elements to give the complete structure, see figure 12. The problem was run on the PDP-15 minicomputer using the GIFTS-3 package. Results included overall behavior of the model as well as detailed, stress and deflection results in the individual substructures. Results are not shown here due to space considerations.

Analysis of Tubular Joints

Tubular joints are of importance, particularly in the case of offshore structures. The constrained substructure technique is used here to provide both overall behaviour and detailed stress distributions at the joints. In this case a two-dimensional tubular frame was modeled using beam elements, except at the joints, where a more detailed substructure was employed, see figures 13 and 14. Constraint conditions were applied at the substructure/beam interface to ensure compatibility. The results show the deflections of the frame under load, see figure 13, as well as the stress distribution in the joint, see figure 15.

CONCLUSIONS

A general purpose interactive, graphics oriented, finite element program has been described, which has applications in ship structure analysis, both static and dynamic, as well as in preliminary ship design. Its suitability for minicomputer application, as well as its dual role as a pre- and postprocessing and an analysis tool, give it a certain uniqueness in today's increasingly minicomputer dependent engineering environement.

ACKNOWLEDGEMENTS

The author gratefully acknowledges the support of the Office of Naval Research under contract no. N00014-75-C-0837, the United States Coast Guard under contract no. DOT-CG-43565-A and the Gifts Users Group members for the support leading to this paper.

Special thanks are also due to Michael W. McCabe and Richard M. Osgood for their technical support, and to Ms. Maria D. Pinedo for help in preparing the manuscript.

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[4] H. A. Kamel and M. W. McCabe, Direct Numerical Solution of Large Sets of Simultaneous Equations, Aerospace and Mechanical Engineering Department, University of Arizona, Technical Report No. 3, January 20, 1978.

[5] H. A. Kamel, M. W. McCabe, & P. G. DeShazo, Optimum Design of Finite Element Software Subject to Core Restrictions, ONR Technical Report No. 4, Contract No. N00014-75-C-0837, April 1978.

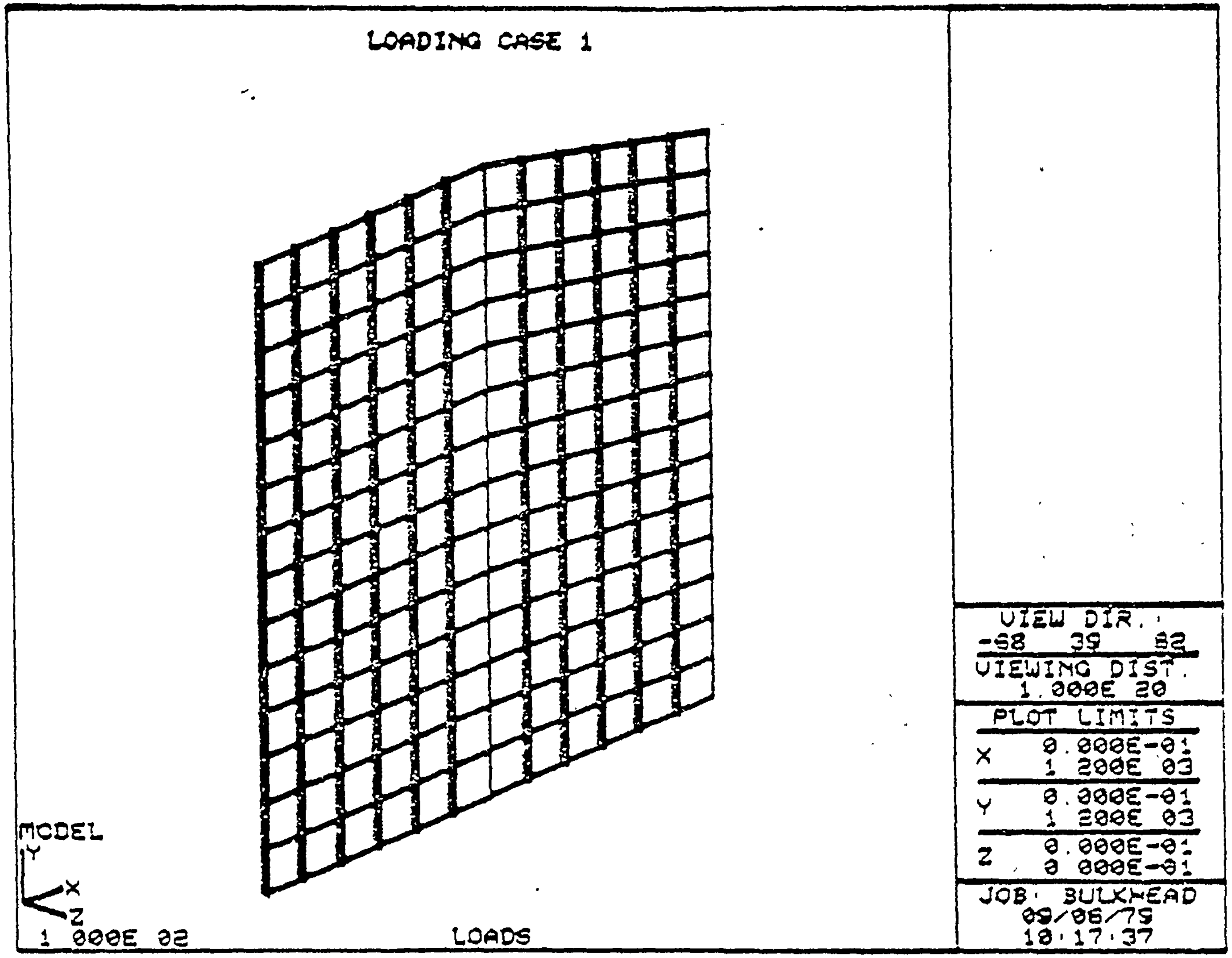

Figure 1. Finite Element Model of a Stiffened Bulkhead

```
MSTEEL/l/0
ETH,1/1/0.8,/0
TBEAM,10/2/30,20/0.7,0.9/0,0/0
KP0INT/1/,,/2/600,,/3/1200,,/4/0,1200/5/600,1200/6/1200,1080/0
LETY/BEAM2/1,2
SLINE/L12/l,2,7/L23/2,3,7/L45/4,5,7/L56/5,6,7
L25/2,5,15/L36/3,6,15/ /
SLINE,1/L14/1,4,15/5/ /
GETY/QB4/1,1
GRID4,2/G1/L12,L25,L45,Ll4/G2/L23,L36,L56,L25/  /
END
```

Commands to Generate Structural Model

```
SUPG,6/Gl/G2/ /
SUPL,l/L14/L45/L56/Ll2/L23/
SUPL,2/L25/L36/
SUPL,3/Ll2/L23/L36/L45/L56/L25/
SUPL,5/L14/
LDCASE/l
HEADG,2/Gl/0.,0.8/800.,0./Gl/0.,-0.6/600.,0./  /
LDCASE/2
HEADG,2/G2/0.,0.6/600.,0.,-0.8/800.,0./  /
LDCASE/3
HEADG,2/Gl/0.,0.8/800.,0./Gl/0.,-0.6/600.,0./  /
HEADG,2/G2/0.,0.6/600.,0./G2/0.,-0.8/800.,0./  /
END
```

Commands to Apply Boundary Conditions and Loads
To Bulkhead

Figure 2. Commands for Model, Boundary Condition and
Load Generation for Stiffened Bulkhead

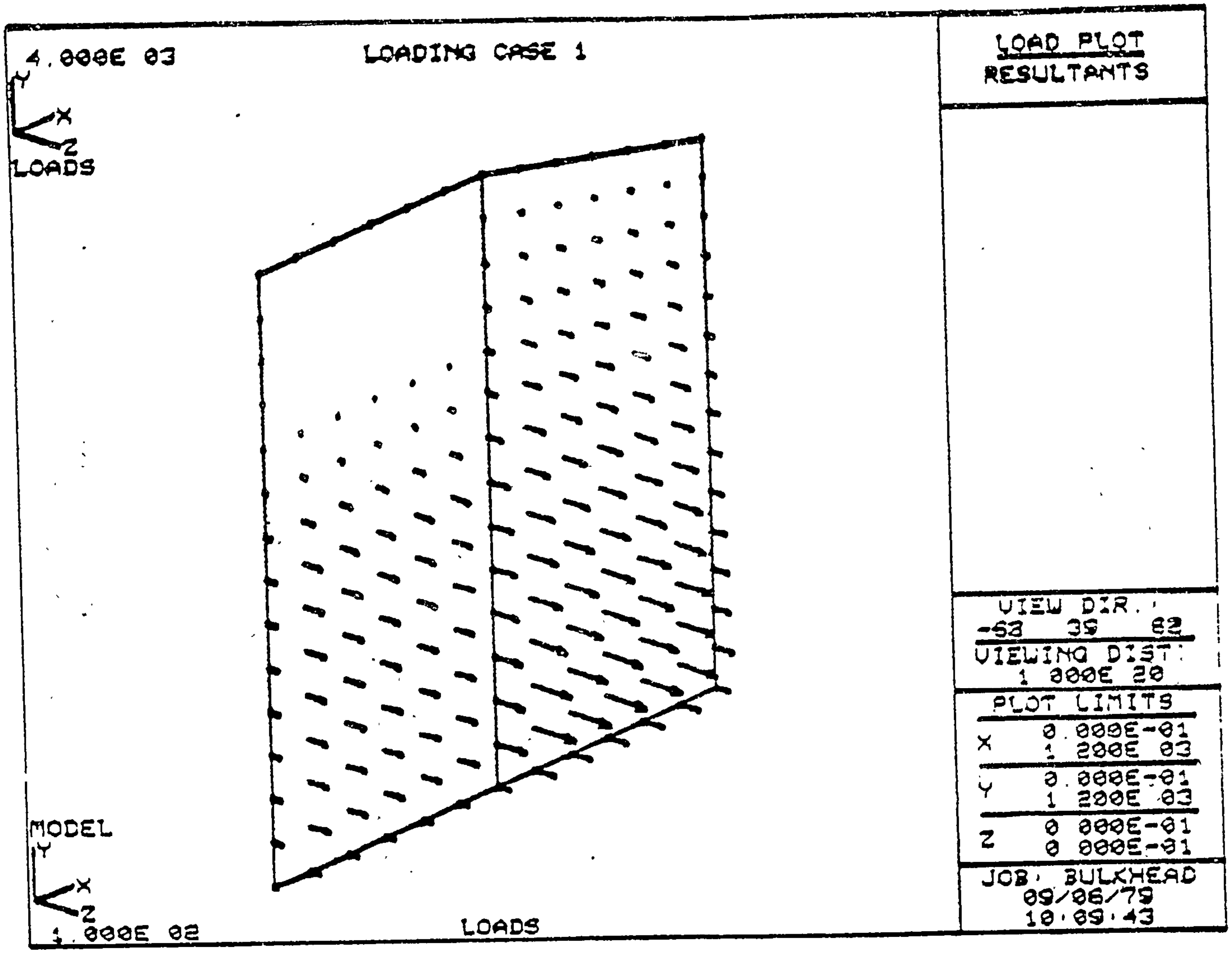

Figure 3. Hydrostatic Pressure Loading on Transverse Bulkhead

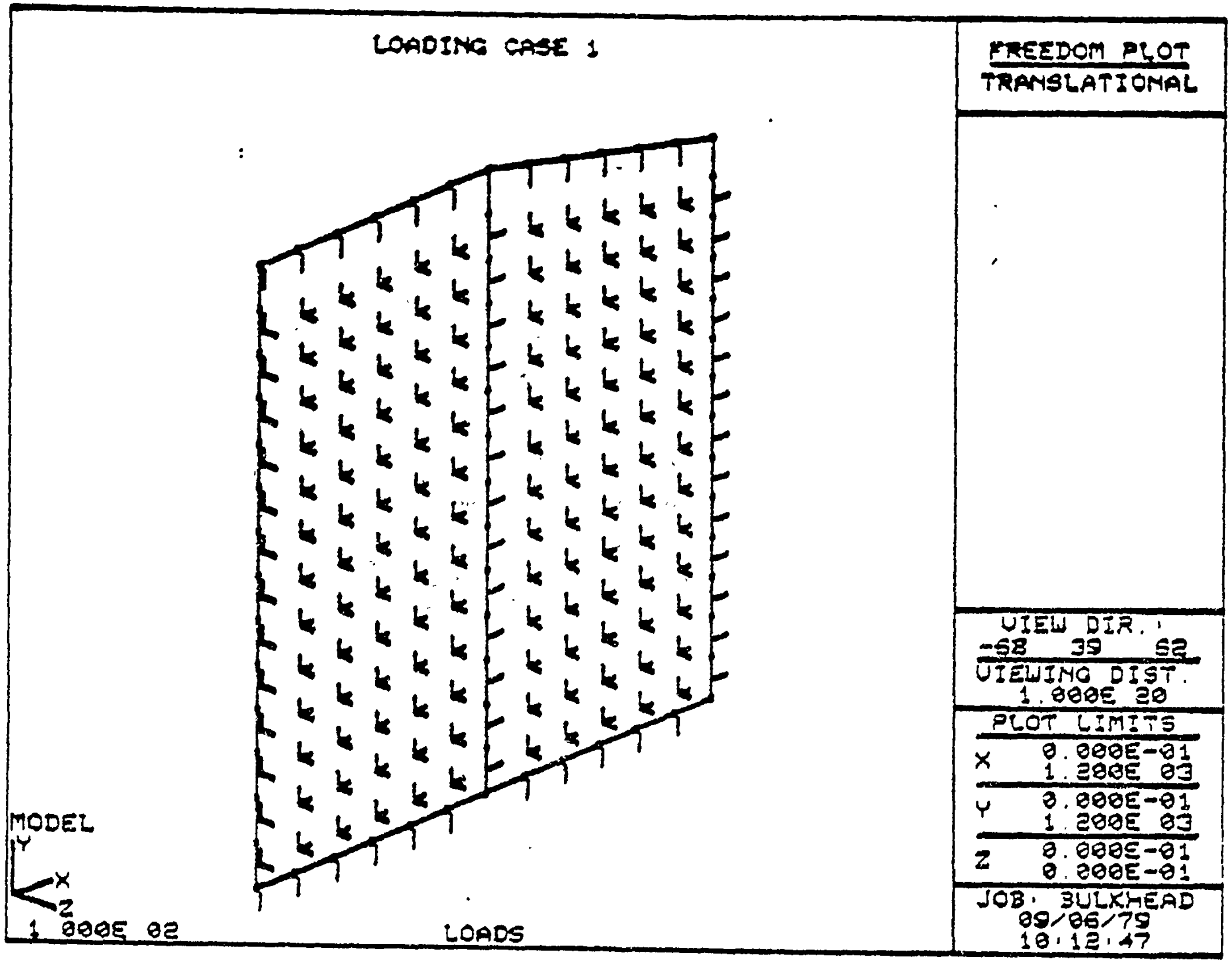

Figure 4. Translational Freedom Pattern for Bulkhead Model

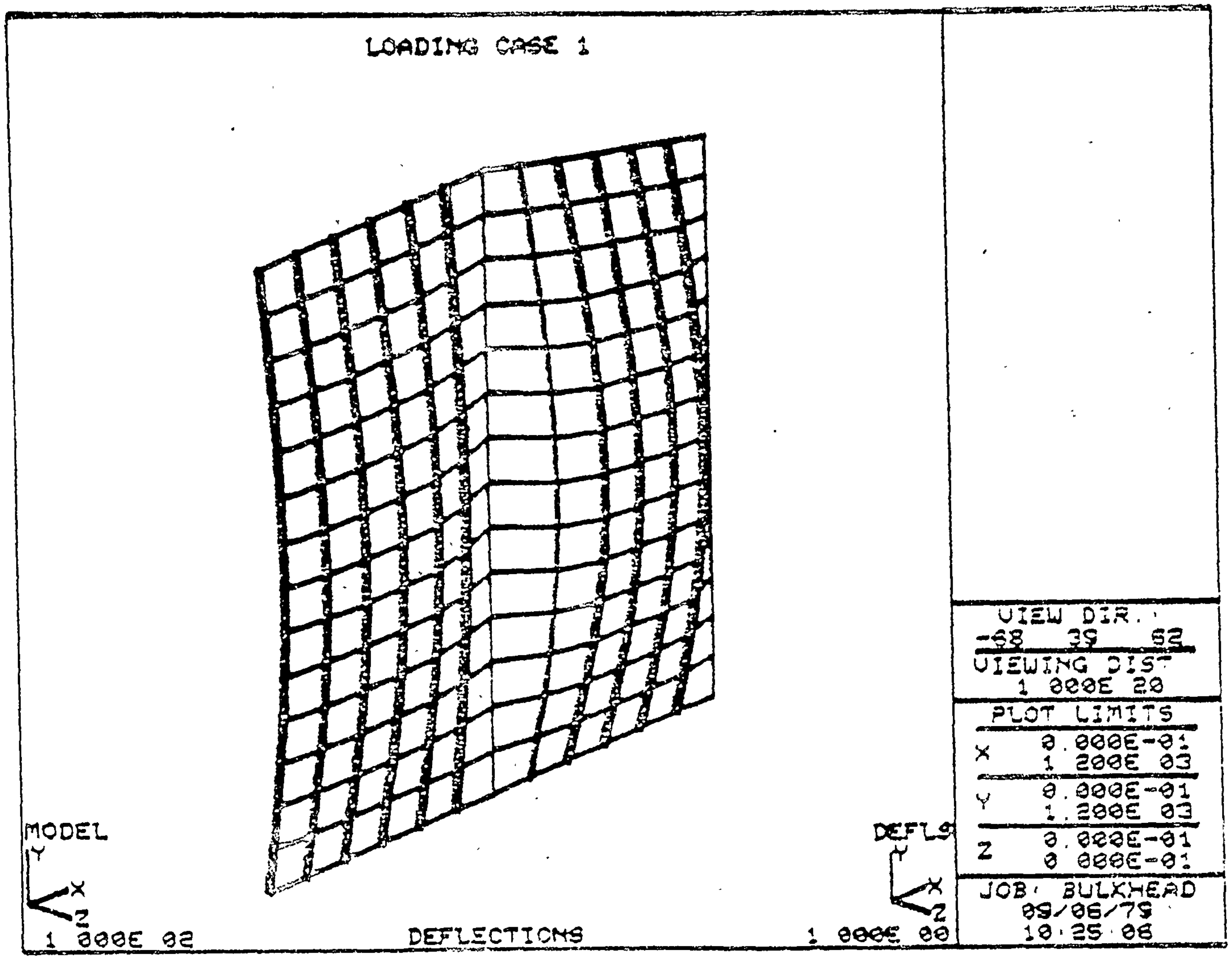

Figure 5. Deflections of Bulkhead under Hydrostatic Pressure

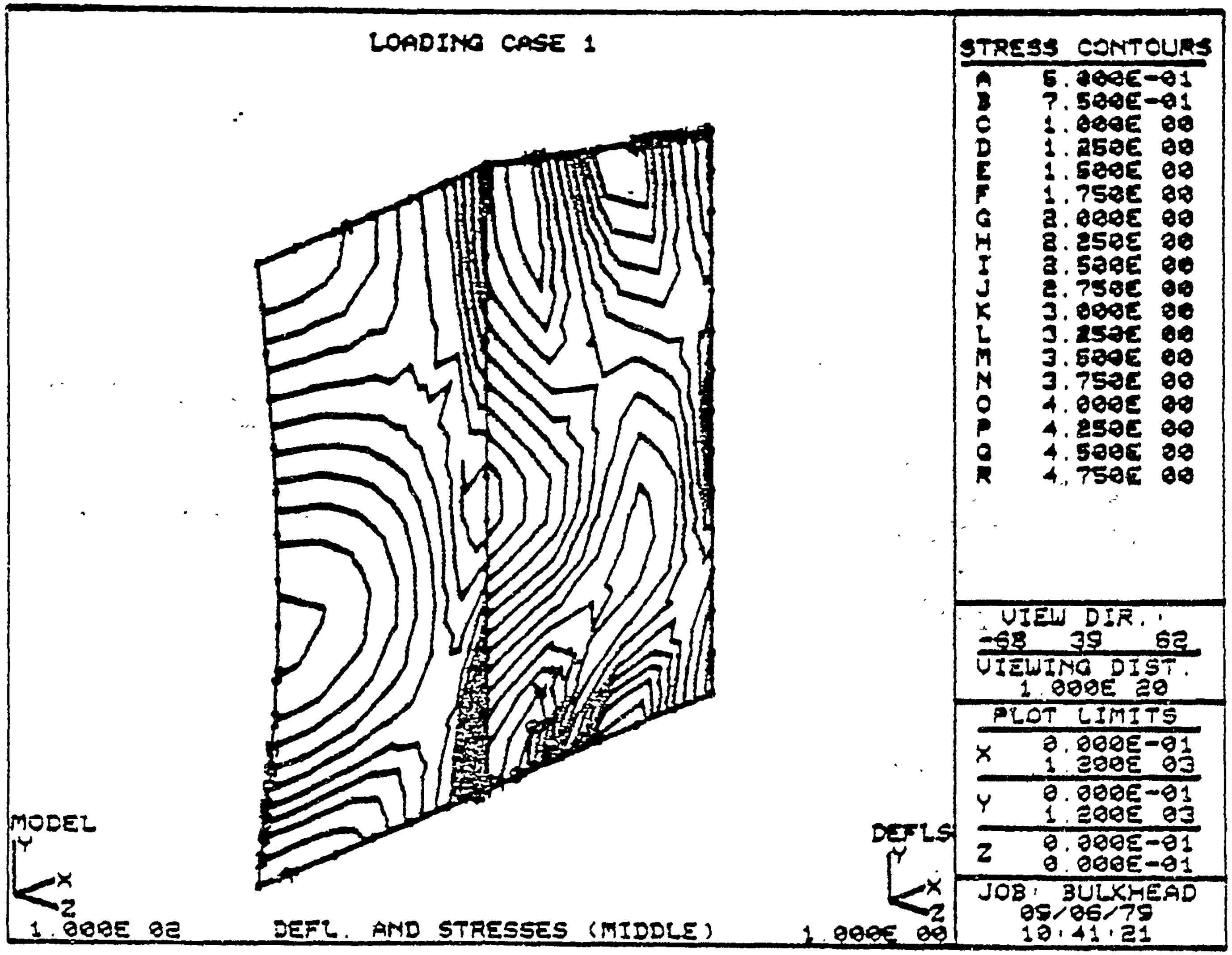

Figure 6. Von-Mises Stress Contours in Bulkhead Plating

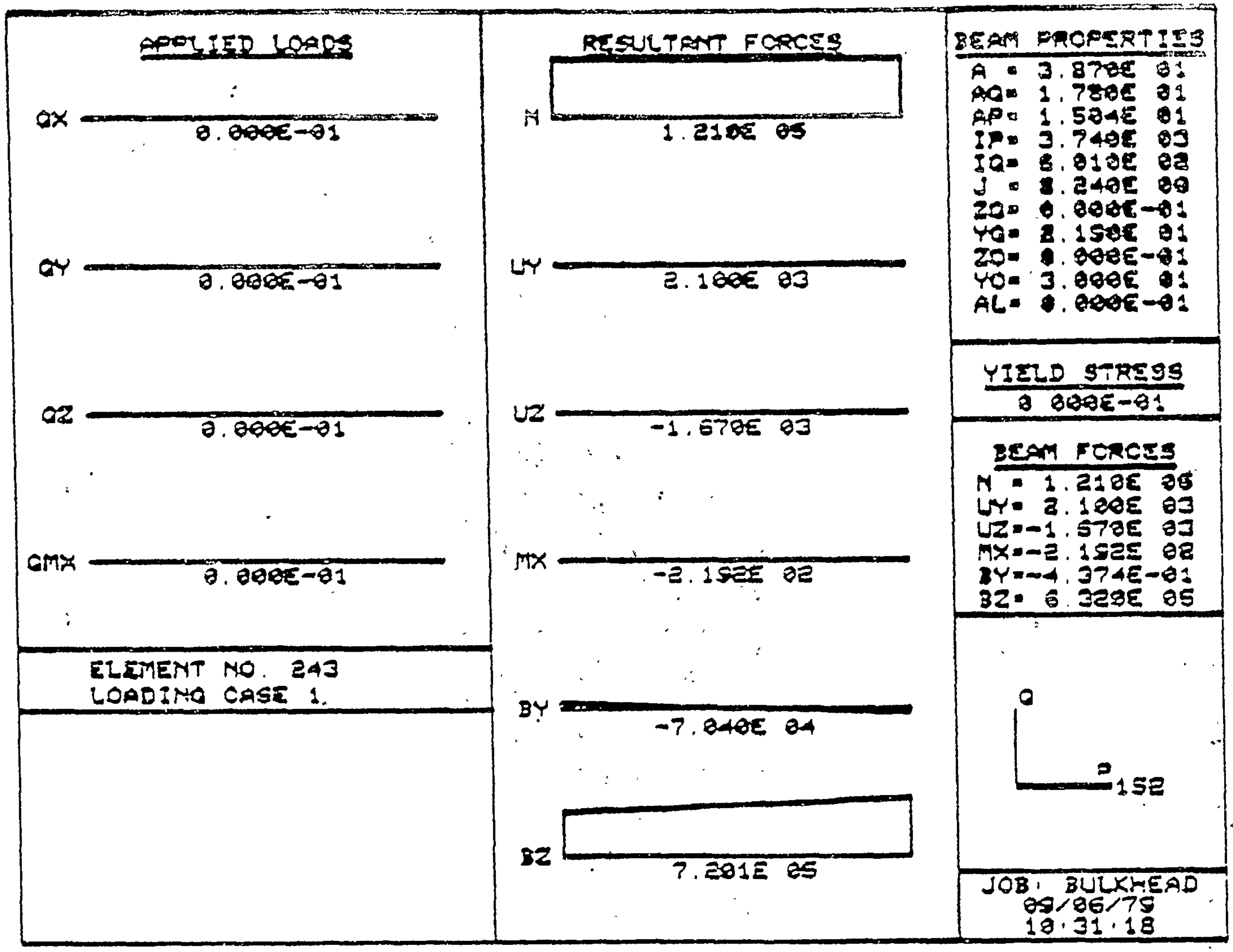

Figure 7. Load, Shear Force and Moment Diagrams for Typical Stiffener Element

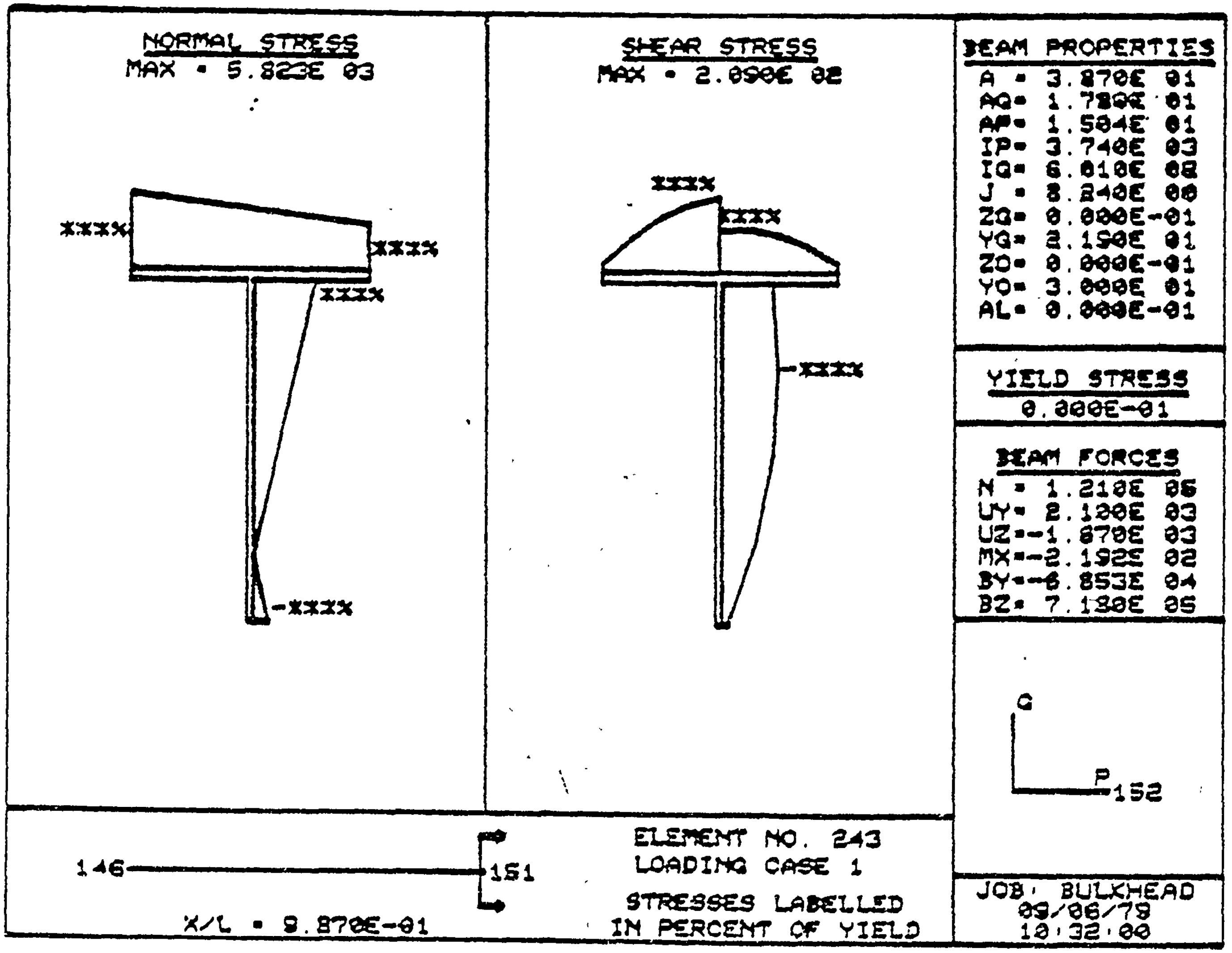

Figure 8. 'Detailed Stress Distribution on Beam Cross-section

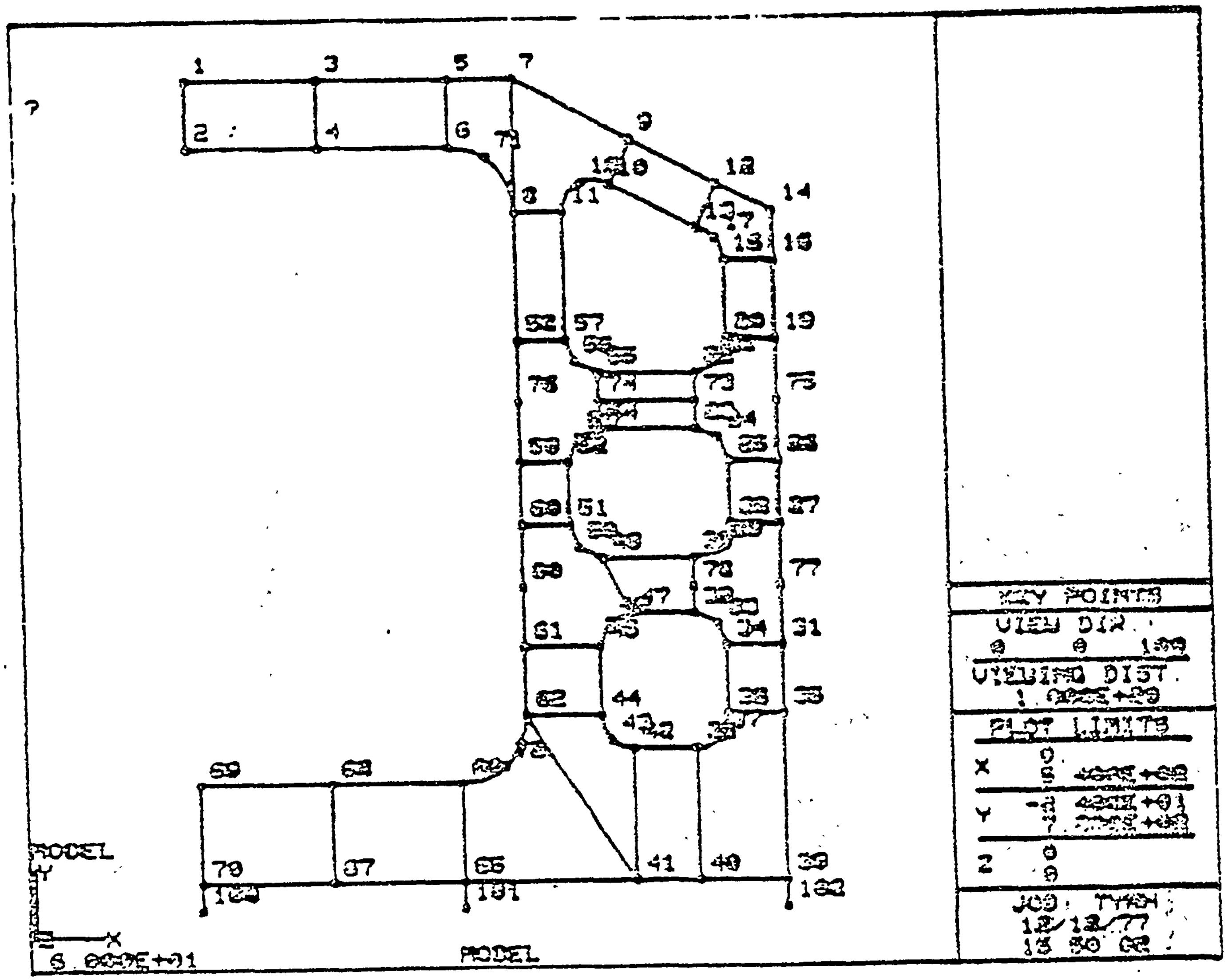

Figure 9. Subdivision of Webframe into Grids

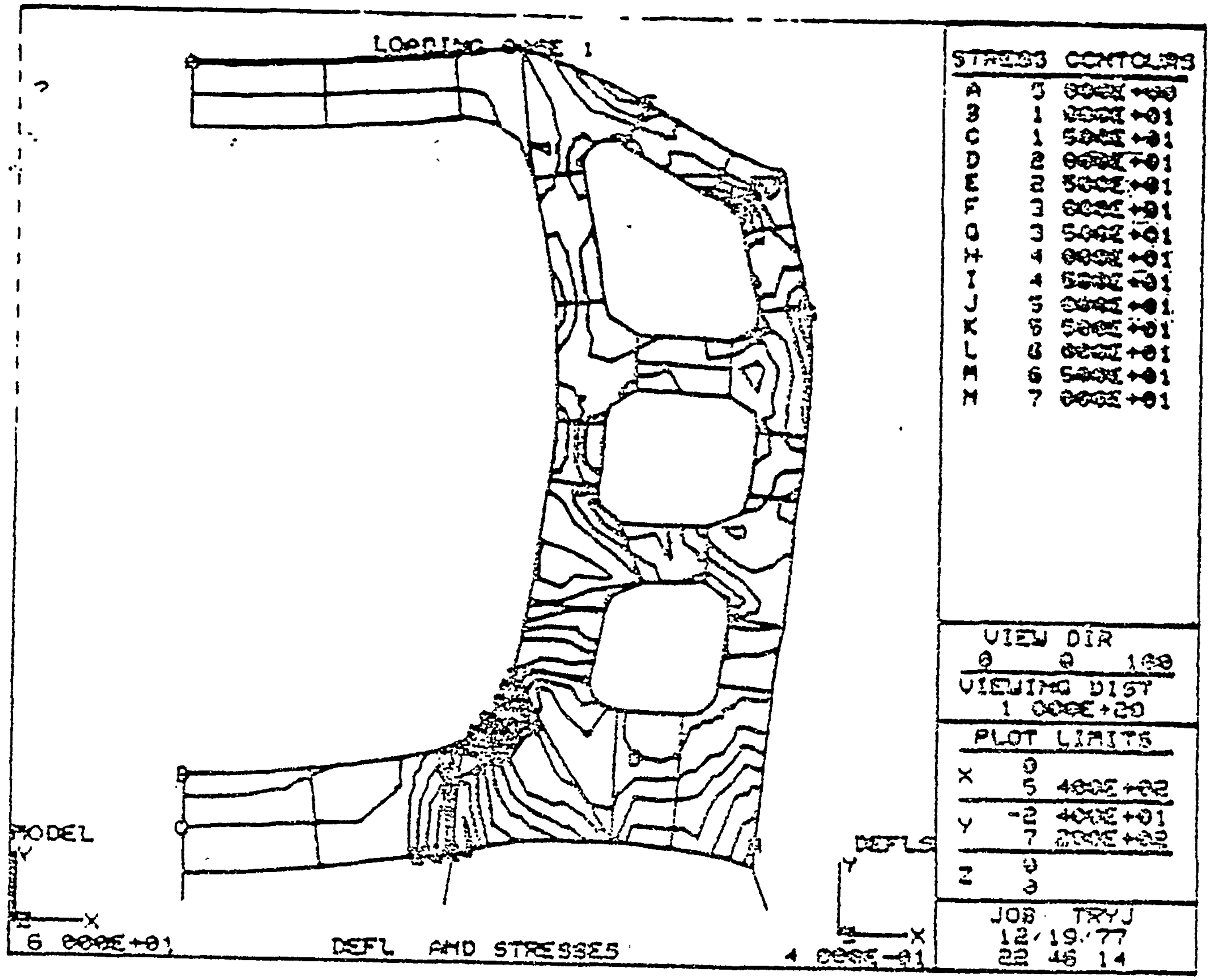

Figure 10. Stress Contours in Webframe Structure

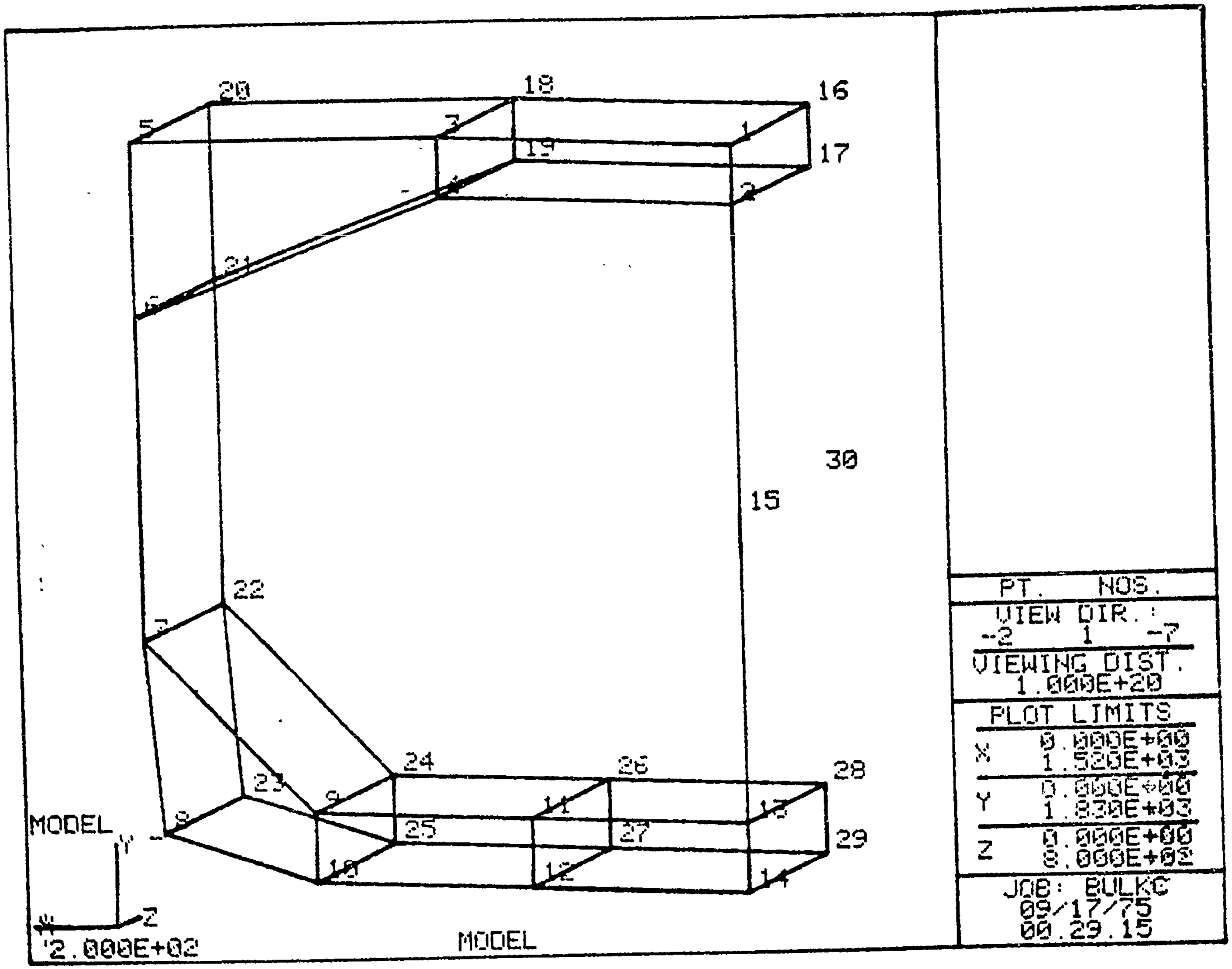

Figure 11. Subdivision of Bulk Carrier Bay into Substructures

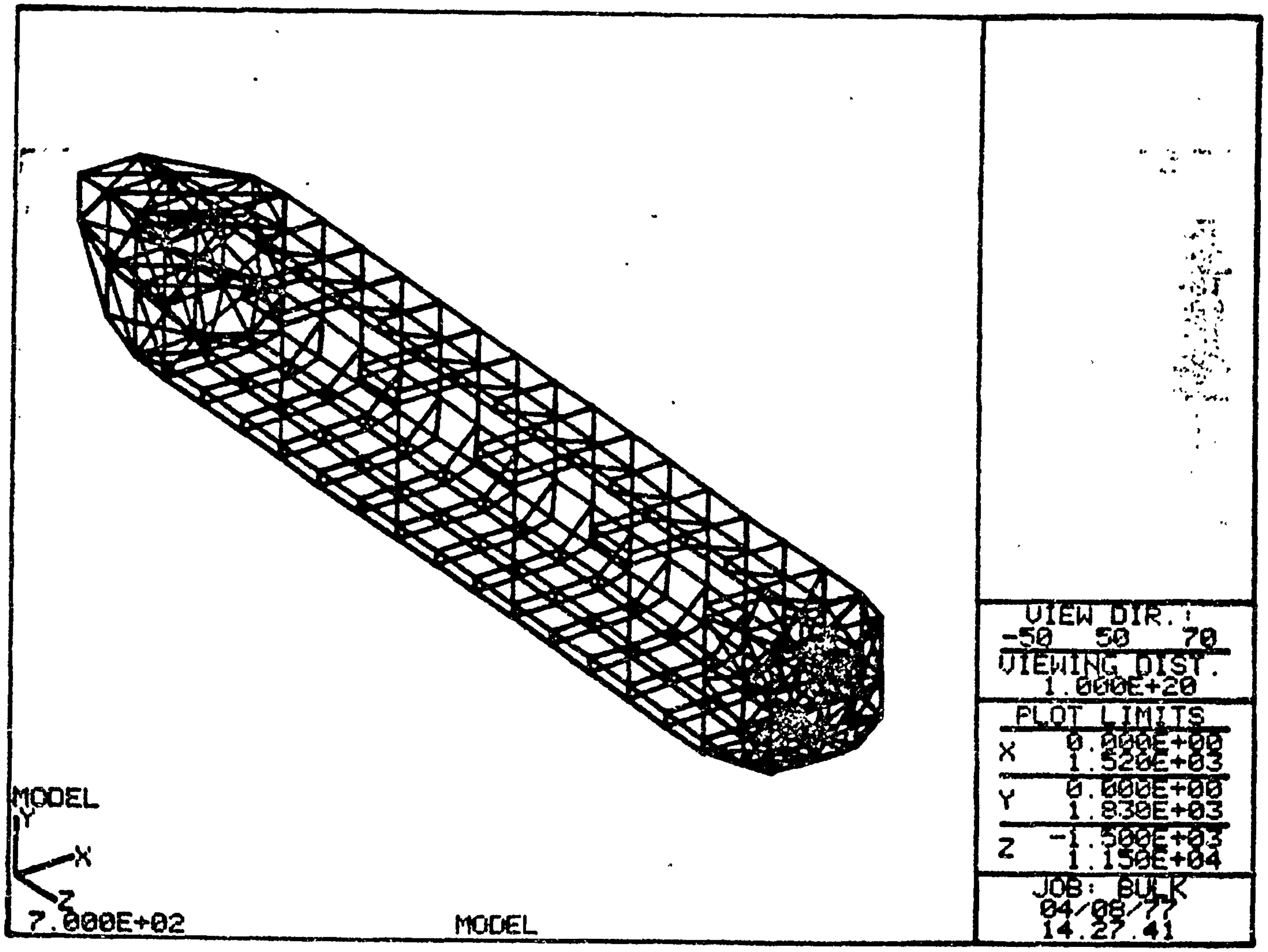

Figure 12. Complete Bulk Carrier Model

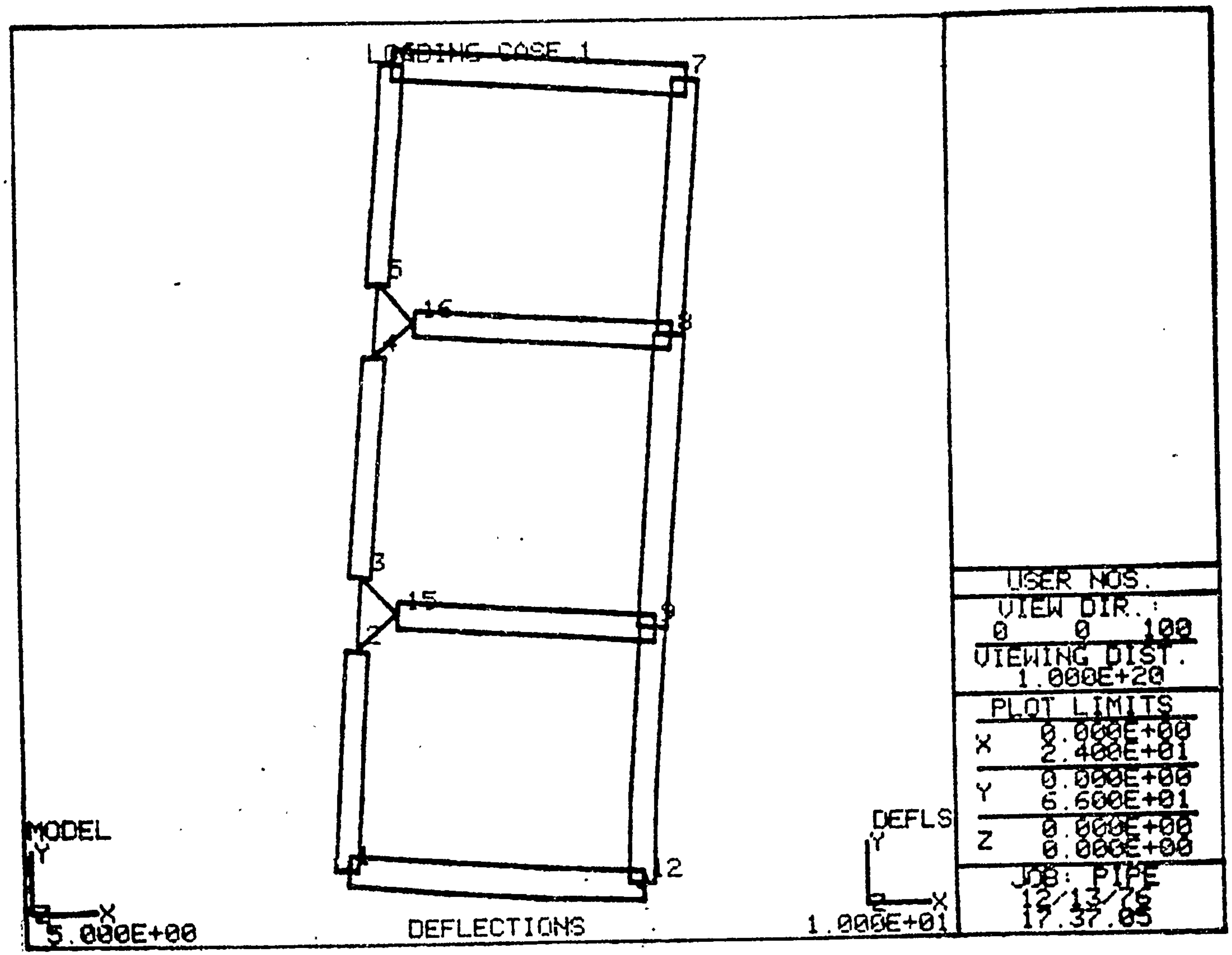

Figure 13. Two-Dimensional Tubular Frame Modeled Combining
Beam Elements and Constrained Substructures

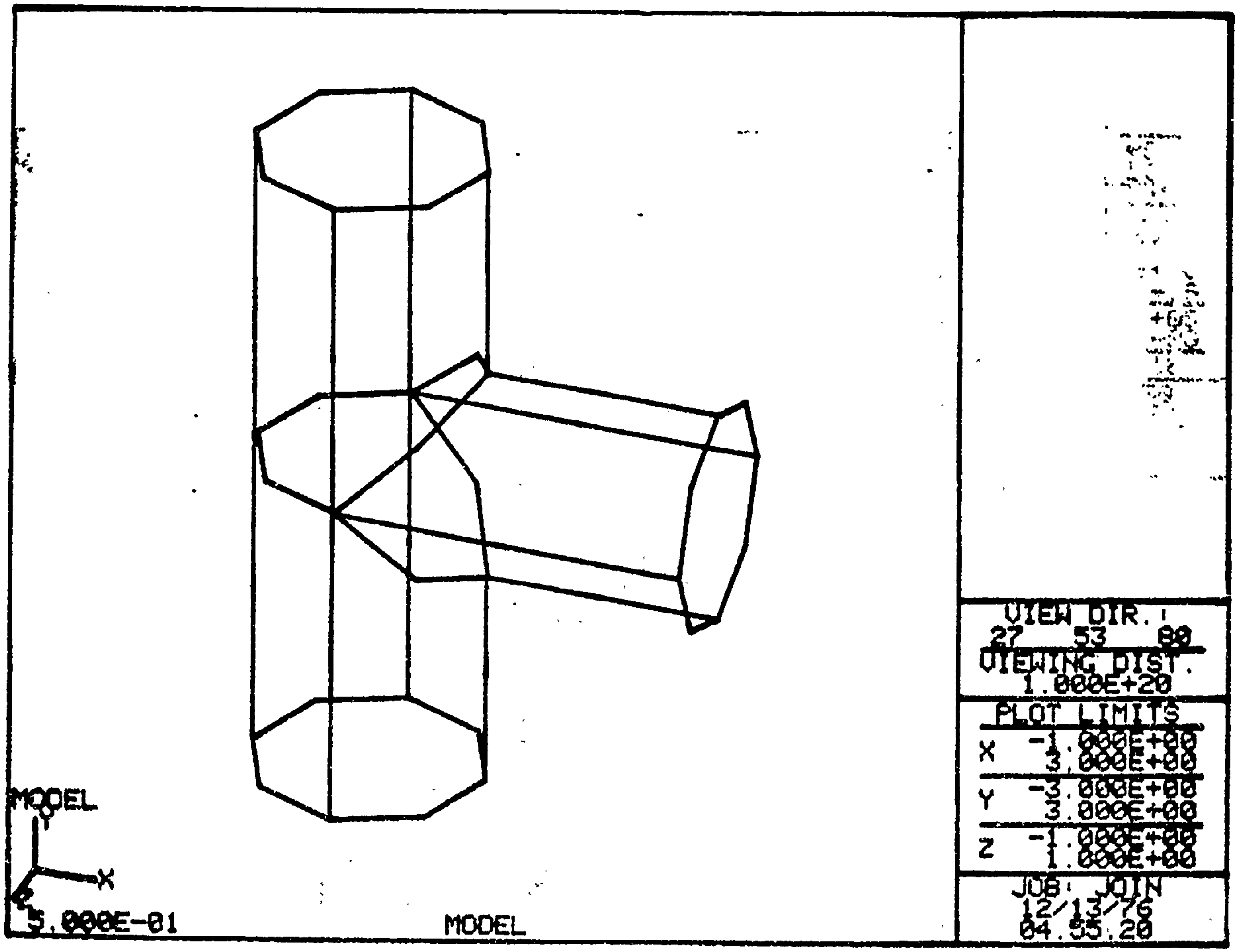

Figure 14. Outline of Grids Used to Model Tubular Joint

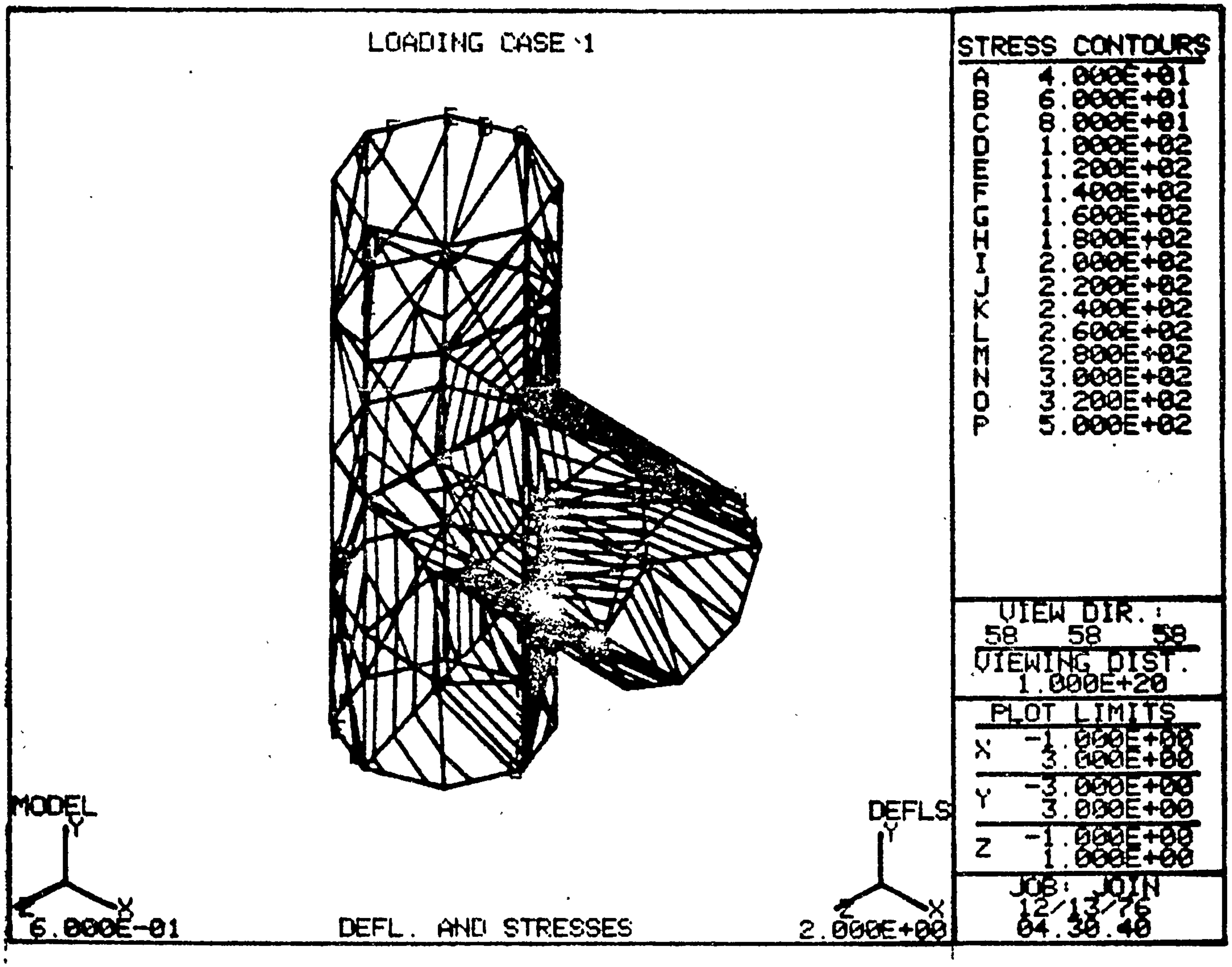

Figure 15. Detailed Stress Distribution in Tubular Joint

DATA PROCESSING TRENDS AT ITALCANTIERI: PRESENT SOFTWARE PRODUCTS AND FUTURE PLANS

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Technical Applications Leader
Italcantieri, S.P.A.
Trieste, Italy

Mr. Banda as Technical Applications Leader is currently responsible for the development of technical software and the marketing of software and services.

Mr. Banda has his Doctorate in naval architecture and mechanical engineering. He previously served as Project Leader in charge of technical software development both for basic and detailed computer-aided design and manufacturing.

Renzo Di Luca
Project Leader
Italcantieri S.P.A.
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Mr. Di Luca as a Project Leader is currently responsible for the design and development of a system for the Advanced Interactive Design for Ships, known as AIDS. Mr. Di Luca is a graduate of the Istituto Nautico in Trieste, Italy, with a degree in naval architecture. He has previous experience with workshop and mould loft applications, numerical control, part coding, fairing, the analysis and development of the SCAFO system, and the integration of SCAFO with AUTOKON.

1. OVERVIEW OF ITALCANTIERI

Today ninety per cent of the Italian shipbuilding industry is nationalized and is controlled by FINCANTIERI, a,holding of the IRI Group. This represents the biggest shipbuilding and shiprepairing organization within the area of the Mediterranean sea.

During the 1960's FINCANTIERI undertook a complete review and overhaul of Italian shipbuilding, with the objective of producing a new efficient and competitive organization. As a result of a series of studies which took place at that time, the decision was made to create a single shipbuilding company, with a size and structure capable of allowing:

- the development of products of a uniformily high standard, which were to be competitive within the market place;
- wide use of centralized research and development facilities during design phase;
- specialization within each shipyard in production of particular kinds of ships;
- use of advanced production technologies and automation of production itself.

The final result of FINCANTIERI's review was the creation in 1966 of ITALCANTIERI, through the merging of three old Italian Shipyards, at Monfalcone, Genova Sestri, and Castellammare di Stabia. These tree yards remain today the primary production centres of ITALCANTIERI. A further two yards, - Muggiano at La Spezia and Orlando at Livorno - which also belong to the FINCANTIERI Group - are operationally and technically associated with ITALCANTIERI.

The headquarters of ITALCANTIERI are located in Trieste, but the three shipyards are situated at considerable distances from the headquarters. Monfalcone is the nearest, being twenty miles away, Genova

ITALCANTIERI'S YARDS LOCATION

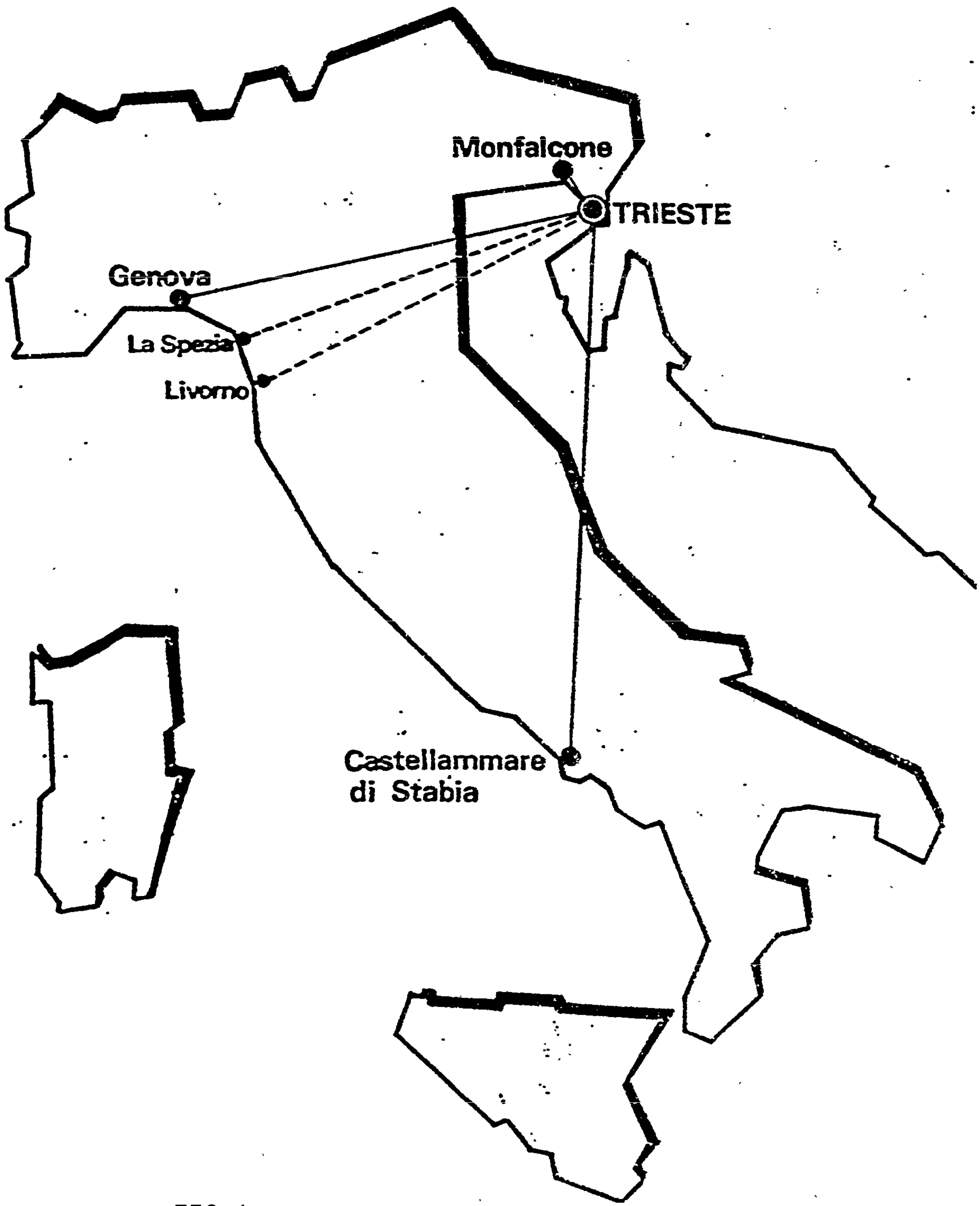


FIG:1

Sestri is about 400 miles, and Castellammare di Stabia, near Naples, is 750 miles away. (See Fig. 1).

The production capacity of the three shipyards is over 1.5 million dead-waight-tons (d.w.t.) per year. This comprises all types of ships, both merchant and naval: tankers up to 350.000 t.w.t., bulk and ore/oil carriers, cargo ships, container ships,- passenger, ferry, refrigerator, Liquid Natural Gas vessels, etc.

ITALCANTIERI now employs about 11,000 people.

2. GENERAL PHILOSOPHY OF ORGANIZATION

At the time of its foundation, ITALCANTIERI faced a number of managerial problems, of which the main were the following:

number of staff at each of the three shipyards, related to the respective peak production workload, was too high for the new organization;

design and workshop documentation standards, organizational approach to the job, departments dealing with external entities (such as classification societies, ship-owners, and suppliers) were so different that mutual co-operation was virtually impossible.

ITALCANTIERI decided that the solutions to the problems deriving from the merging could be achieved through the application of three general principles within the new organization. These were:

centralization of technical and administrative functions;

establishment of Methods Offices in each major department;

recognition of the critical role of DP, and the decision to invest resources in its exploitation.

Centralization

The creation of ITALCANTIERI from the three existing shipbuilding firms was accompanied by the decision to establish, at the headquarters in Trieste, centralized departments responsible for general scheduling, sales, finance and accounts, design and purchasing. This centralization inevitably brought about certain problems in communications. These were anticipated by ITALCANTIERI, but it was felt that the advantages conferred by centralization far outweighed any disadvantages that would arise. The main advantages were:

- the merging and consequent augmentation of experience of technicians coming from different yards;
- the ability to distribute the total workload evenly over the work force available, avoiding peaks and troughs at a particular yard;
- more efficient and effective co-ordination and control of the functions of the whole organization;
- creating of a structure more amenable and receptive to improvements and innovations in working methods and technology.

Methods

In each of the following major departments within the new organization a Methods Office was set up:

- basic design;
- detail design;
- production;
- personnel;
- finance and accounting;
- each shipyard.

These offices were responsible for the improvement of procedures, the development of standards, the study of new production technologies,

and the definition of new facilities and plants. (Altogether more than 100 people are involved in these Methods Departments today).

DP Development

Within the new organization the role of the DP department was given a primary importance and significance. From now on it was to include not only the achievement of minor costsavings and timesavings in the production and design functions, but would operate as an influence throughout the organization in promoting a rigorous critical analysis of every job done and the methods used to do it. The objective was to encourage, and almost to force, the development of improved procedures and methodologies.

Today the personnel assigned to development of new systems number nearly 200 employees: 60 are analists and programmers and the remaining are users directly involved in the systems definition and development.

3. PRINCIPAL CHARACTERISTICS OF THE D.P. SYSTEM AT ITALCANTIERI

The peculiar structure of the Company allows a considerable degree of rationalization of some functions on one side, but on the other side causes some specific problems as far as design and workshop documentation are concerned.

And particularily the latter must be taken care of in its smallest details so that the shipyard can be completely independent and does not need further work from draftsmen and engineers.

For this reason D.P. systems have received the utmost care as for the aspects of exactness and exaustiveness of information.

This information system was not conceived as a single entity, but consists of a number of systems, started at different times during the

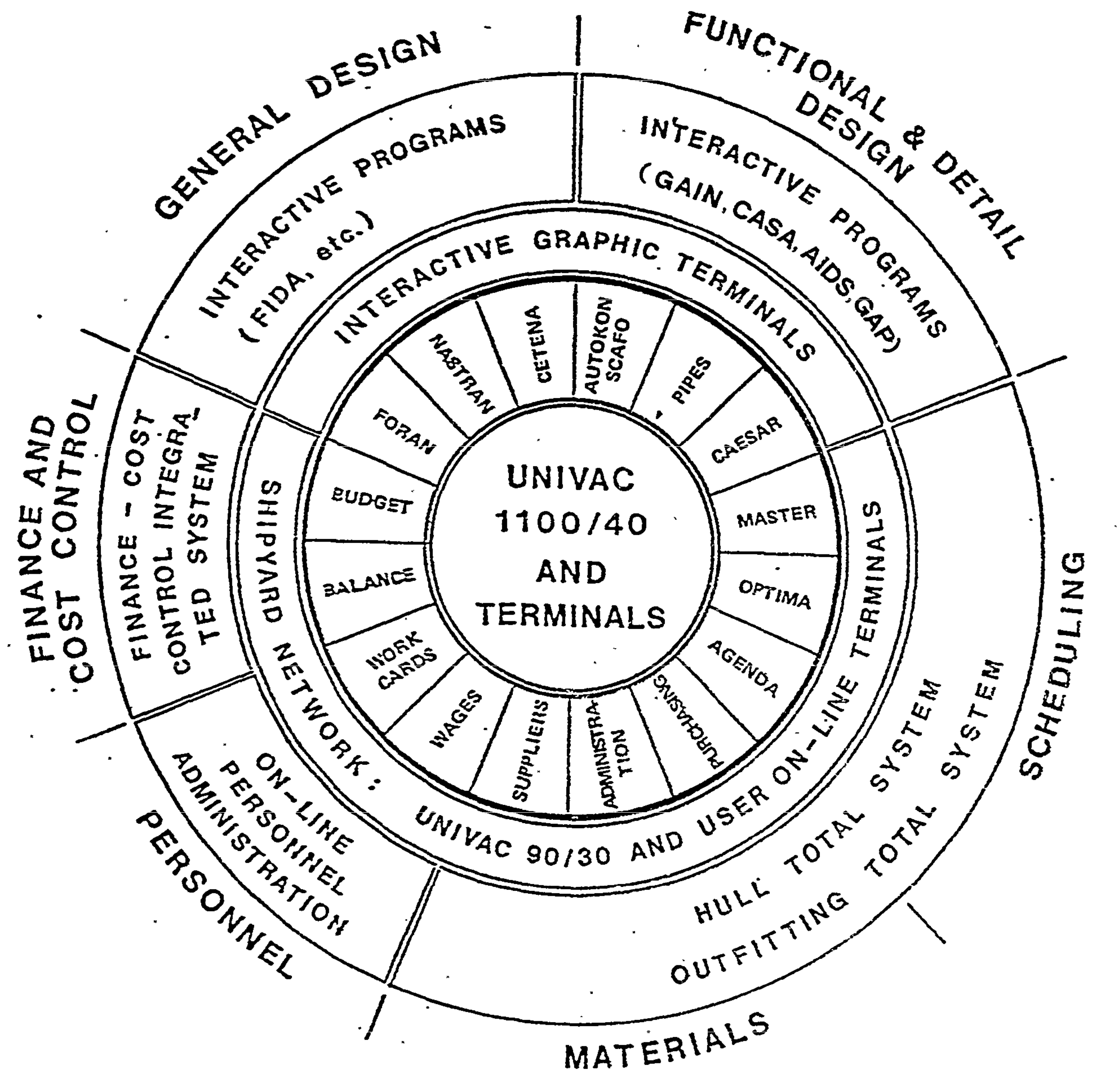

GENERAL DESIGN
FUNCTIONAL & DETAIL DESIGN
INTERACTIVE PROGRAMS (FIDA, etc.)
INTERACTIVE PROGRAMS (GAIN, CASA, AIDS, GAP)
INTERACTIVE GRAPHIC TERMINALS
NASTRAN
CETENA
AUTOKON SCAFO
PIPES
CAESAR
MASTER
OPTIMA
AGENDA
PURCHASING
ADMINISTRA-TION
SUPPLIERS
WAGES
WORK CARDS
BALANCE
BUDGET
FORAN
UNIVAC 1100/40 AND TERMINALS
SHIPYARD NETWORK: UNIVAC 90/30 AND USER ON-LINE TERMINALS
FINANCE AND COST CONTROL
FINANCE - COST CONTROL INTEGRA-TED SYSTEM
PERSONNEL
ON-LINE PERSONNEL ADMINISTRATION
MATERIALS
HULL TOTAL SYSTEM
OUTFITTING TOTAL SYSTEM
SCHEDULING

FIG. 2

past years, all of which were designed to serve the overall objectives of the company as a whole.

The system is still not complete but continues to develop, becoming increasingly more comprenhensive in its power and scope. As it expands the need for computer hardware increases, to provide additional on-line facilities and computer processing time.

The range of applications described in the following paragraphs runs on a considerable network of interactive and batch terminals based on an Univac 1100/42 at the central processor, satellite 90/30 processors at each of the three shipyards, a Kongsberg RJE with two drafting machines, on ADAGE GS/340 interactive graphic terminal with two consoles, a PDP 11/70 with an ADAGE GP440, TEKTRONIX 4014 and alphanumeric terminals at the detail design department and, at last, several alphanumeric terminals directly connected with the main frame for administrative applications.

3.1 Outline of Italcantieri D.P. Information System

The application software modules constituting the system are ‘shown diagramatically in Fig. 2.

The figure clearly shows how:

I) all design and administration activities are covered by D.P. systems;

II) some systems (like FORAN, NASTRAN, AUTOKON, OPTIMA) were purchased abroad either in order to overcome initial software shortage or because in any case home development of the product would not have been profitable at that time;

III) the Company has spent a considerable amount of energies in the last years in order to develop interactive applications in the field of design, and real-time and data base oriented activities applications in the fields of administration and control of materials.

As it is not opportune to make now a detailed description of the single systems, mention will be made of their respective utilization fields and then a detailed description will follow of four systems which are the most interesting from the point of view of mutual integration which will successively lead to the realization of a new generation of Italcantieri information system especially in the technical field.

General Design

FORAN - a design system based on the mathematical definition of the hull form.

CETENA - for hydrostatical calculations, and checking loading and unloading conditions.

STRUCTURAL ANALYSIS - using the packages NASTRAN, SESAM and FRENAT.

AUTOKON 74 - for the generation of parts as far as the internal structure in concerned.

SCAFO - for structure definition, drawings, generation and preparation of documents and technical information for hull production.

PIPES - for detail design and workshop documentation for piping production.

CAESAR - for the design of electrical plant.

GAIN - for interactive part definition and nesting.

CASA - for interactive ship accomodation.

Scheduling

MASTER SCHEDULE - for determining the time of the major events in management of ship construction.

AGENDA - for timing and control of detail design Dept. and shipyard activities.

OPTIMA - as basic software for the management of network techniques.

Materials

PURCHASING SYSTEM - for order handling and control.

ADMINISTRATION - for periodical follow-up of the warehouse and materials accounting.

SUPPLIERS - for materials suppliers book-keeping.

Personnel

WORK CARDS - for the handling and accounting of Work Cards.

WAGES - for wage calculation and personnel administration.

Finance and Cost Control

BUDGET - for monthly check of cost of each ship under construction.

BALANCE - for handling all legally required auditing tasks.

3.2 HULL, SCAFO, GAIN, CASA, PIPES SYSTEMS

The reasons for the presentation of these four technical systems as indices of the level reached within Italcantieri are that we can prove that utilization of these systems is followed by positive results and that they cover more than 90% of all design activities; moreover these systems will constitute the basis of the new integrated design system which is being developed within Italcantieri.

HULL System

At Italcantieri, the whole production cycle for hull construction, from general design to the definition of each elementary component, is performed with an intensive use of specialist skills and production facilities. Consequently, Italcantieri's shipyards are today equipped with the most advanced tools available for material handling and working.

The technical and economic importance of hull construction has for

many years forced the Company to concentrate its own specialist resources in the development of DP systems that are considered essential tools in order:

I) to guarantee competitive products of the highest quality;
II) to rationalize the manufacture of these products.

In the development of such systems the Company has not hesitated to purchase packages from other Organizations whenever these could allow the attainment of the highest possible standards in the shortest possible time.
The computerized systems are operational today in the area of:

- Hull Design.
- Hull Production.

The system for hull design is principally beneficial in those areas of the process requiring creative development, relieving the designer of the need to carry out complex and sophisticated calculations and drawings manually, and of course reducing the time taken very considerably.
The system for hull production has made the greatest impact in the detail design area, where so much of the work is repetitive and where it is necessary to produce large amounts of printed output in different forms. Such a system, which is the very foundation of a rational use of materials and machinery, allows Italcantieri today to achieve the following goals:

- establishment of a logical and automatic connection between executional and detail design and production;
- automatic preparation of supports- for production processes;
- definition of all data concerning raw or semifinished materials;
- definition of the elementary components and their assembly links;
- definition of all basic data required for efficient production control.

SCAFO system

The system has been developed and implemented at ITALCANTIERI since 1972. In 1976 it was also implemented at CNR, and it is used for services by ninety per cent of small yards within Italy.
It is a computer aided instrument dealing with hull structure definition, drawing, generation and preparation.
It has replaced mould loft and part of production office activities, by integrating them with those of technical office.
As far as the structure definition and drawing is concerned a special version of the system has been linked with AUTOKON system under the name of AUTOKON 79.
Philosophy and related functions are briefely described in appendix A.

GAIN (Graphic Advanced Interactive Nesting)

The GAIN system was developed by ITC to solve nesting activity problems, which are critical owing to the high quantity of resources required before the workshop starts its operations.
The system works mainly on an ADAGE GS/340-interactive terminal with some module on the host computer. The modules on host computers perform the following functions:

- retrieval of geometrical description of part coding system from the data base;
- preparation of a booklet containing drawings of all called parts;
- management of data base containing final and intermediate results of nesting operations;
- storing into the material data base of all necessary information for plates purchase;
- transfer of preliminary data and results to and from remote interactive stations;

preparation of workshop drawings, documents, and paper tape for NCFCM.

On Adage side GAIN provides the following interactive modules:

- management of local data base containing preliminary data and temporary results;
- part definition;
- part positioning;
- cutting path definition;
- drawing annotation.

By using traditional procedures and assuming as a basic datum a production of 3000 nestings per year, the traditional nesting activities required about 16 draftsmen who would on the average produce a nested plate per man every 8 hours.

To complete a working batch containing an average amount of 20 nestings, the total elapsed time was about 2-3 weeks.

At present all nestings produced for the company's shipyards are carried out interactively by only two persons.

The average time for each nesting is less than 1 hour of which about half an hour is spent for all non interactive activities.

From the point of view of preparation of workshop documents and of paper tape for the numeric control machines, the result is even more interesting as all operations on one batch are thoroughly performed in 2-3 days.

The system is at present available in the following alternative options:

main frame: UNIVAC 1100, IBM 370

interactive station: ADAGE GS/340, PDPll, plus ADAGE GP400

parts' data base: AUTOKON system, any other system

(for a deep description of GAIN see: "NEW CONCEPTS AND D.P. SYSTEMS ARCHITECTURE IN HULL DETAIL DESIGN", ICCAS 79).

CASA (Computer Aided Ship Accomodation)

This system produces drawings of high quality, bill of materials, orders, and lists for fitting of accomodation.
The CASA system allows very easy handling of data base and modification of rules and standard items, without altering operative programs. The draftsman can handle the program in batch mode for primary input and use interactive mode for corrections and updatings. C.A.S.A. system has three logic modules:

description of standards, this operation is handled in batch mode. In this case the input concerns standard materials description and general selection rules. This kind of data are stored into the data-base of the system; drawings and lists are also provided.

description of ship design data, from design drawings the main data are loaded into the computer for further processing.
All the operations of this phase are considerably simplified (thanks to a particular "user-oriented" language) and do not require specific knowledge of DP. Relevant output drawings will constitute the basic layout of accommodation.

interactive automatic design, from description of construction data and standards, with the aid of interactive functions of C.A.S.A. system, "automatic" and "interactive" designs are developed. Automatic design, which foresees data processing for each constructive detail, is completely handled in its initial phase in batch mode. Interactive design allows corrections and modifications of data and standards, with immediate feedback, thus giving the operator the possibility of a quick and easy communication with the computer.

In details, the system deals with:

- accomodation basic plan
- accomodation basic plan with rooms numbering
- wall panelling plan
- wall panels nesting booklet
- materials withdrawal notes
- summaries of material requisition orders
- pallets subdivision
- door plan
- coamings plan
- joints plan
- furniture plan
- ceilings plan.

The advantages achieved by the system can be summarized as follows:

reduction of work: automatic and complete preparation of bill of materials, of workshop documentation and drawings, has allowed a reduction of manpower from 6000 to 1500 hours per, ship.

reduction of calendar time: automatic processing and interactive check and correction, in addition to dramatic reduction of time for the drawings, have reduced the calendar time from 12 to 5 months.

PIPES (Program for an Integrated Pipes Engineering System)

At Italcantieri general design and production procedure for pipes is characterized by:

definition of functional diagrams
definition of piping runs
issue of operational documents and of the bills of materials
manufacturing of piping elements
erection of piping elements.

It must be borne in mind that the piping functional diagrams correspond directly to the individual ship's plants and services. The production procedure for the piping calls for different exigencies, v12:

- the workshop documents for the pipeshop must allow the most efficient loading of the machinery available, which is organized in a highly automated line
- the workshop documents for the erection must allow parallel progress in the building and assembling of the hull and outfitting elements.

The goal reached by Italcantieri was the harmonization of the present procedure of design, mainly oriented to packages of pipe-lines, with the pipeshop requirements. That is, costs were minimized and optimum utilization of raw materials was achieved.
It is, however, necessary for production process that the workshop documentation and the bills of materials refer to work "flows", into which the yard workshops are organized. In relation to the various methods of production, the main types of workflows are:

- numerical cold bending
- traditional cold bending
- composition bending (sectors and prefabricated bends)
- hot bending.

Further, the working documentation contains the instructions referring to the store, which the raw material has to be drawn from, and to the destination (pallet) of the finished elements, with reference both to treatment following working and to final destination of the various assembly groups (units, blocks, on board),
About 50% of the pipe work at Italcantieri is concentrated on the automated production line, which consist of:

- an automatic store, where approximately 7,000 bars of pipe are kept;
- an automatic cutting station;
- an automatic spot welder for plane flanges
- an automatic flange welder
- a pipe finishing (grinding) station
- a numerical control pipebending machine.

Information control for automatic production line is provided by the computer.

PIPES consists of three fundamental stages:,

storing of general technical data: in a preliminary stage, the loading of the Data Base is provided for; the Data Base contains:

- utilization criteria and technical description of standardized materials for the piping field;
- piping specifications for a particular ship;
- workshop organization and equipment existing in the various yards, with regard to the various production methods.

processing of the assembly groups: after the piping runs have been defined, data pertaining to the various assembly groups are filled on input data sheets, where working conditions and general geometric characteristics of each piping element are indicated.

On the basis of this data, and after a syntactical and logical check, the computer provides for:

- completing the data supplied on the basis of standards and ship's specification, with the definitive list of needed materials;
- defining, also on the basis of the ship's specification and information on workshops organisation, the method of piping elements manufacture, and the operational parameters for bending itself. It also produces paper tapes for the numerical control bending machine;

- producing a mounting booklet consisting of symbolic sketches (produced by a line printer) of the pipes composing the group, and of a list of the mounting fittings;
- storing the information gained up to this point. in the Data Base.

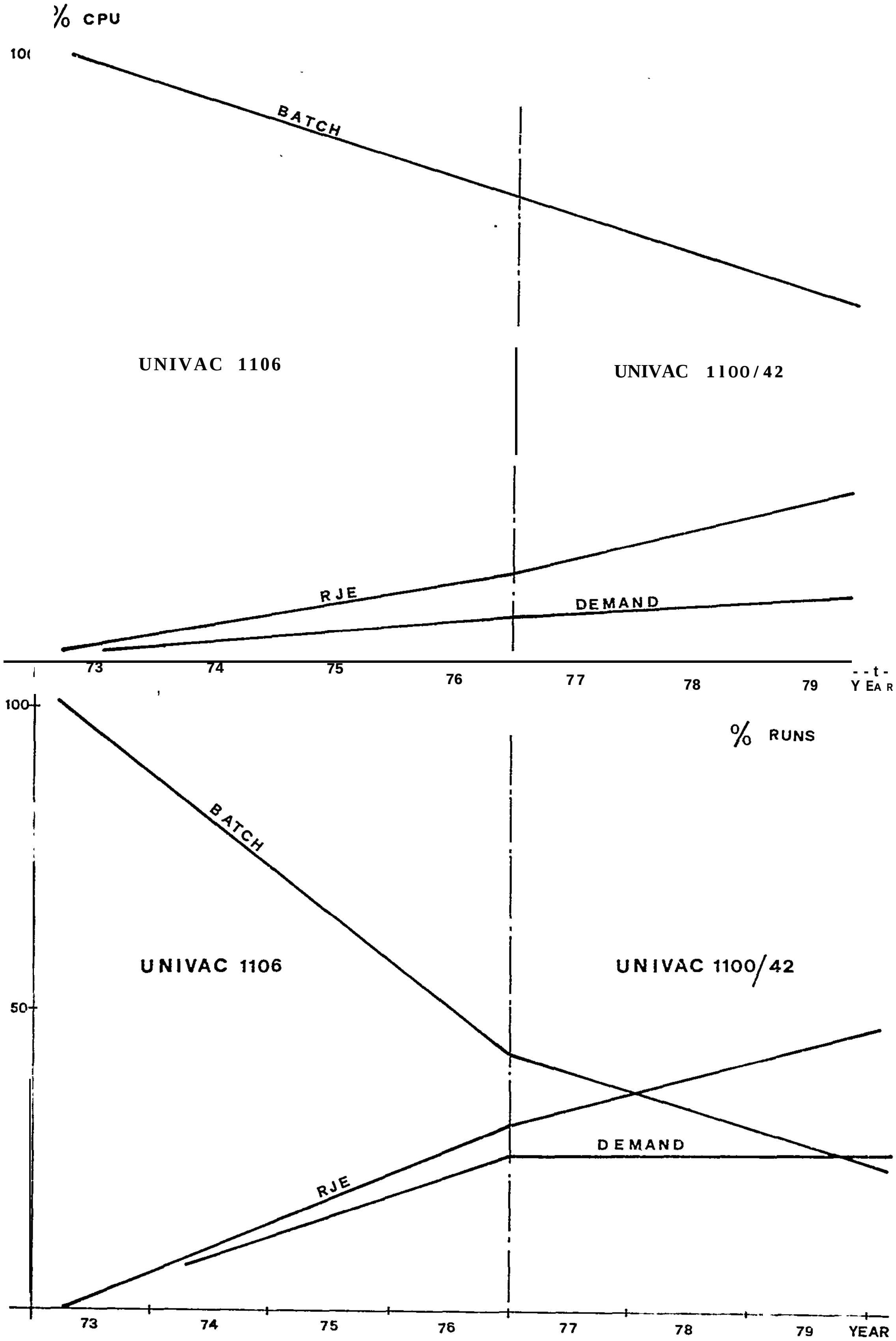
processing of the workshop booklets: working "lots" for the pipe workshops are defined taking into account the quantity of the pipes in the processed zones and their mounting method. Starting with the information contained in the Data Base, the computer provides for each individual flow of work:

- documentation for withdrawal of materials needed for manufacturing;
- "cutting plans", looking for the lowest possible scrap;
- operational supports for numerical control machines;
- sketches for traditional working and finishing platform, produced by Calcomp plotter;
- summary documentation for co-ordinating progress of work and handling of the lot.

The above procedure is integrated with the material handling subsystem developed at Italcantieri.

PRESENT TRENDS OF DEVELOPMENT

In the last years a deep change has been taking place in the final user's attitude while approaching D.P.
As the number of applications was progressively growing and as their presence became more and more important in view of attainment of final documentation, the user was more and more feeling the necessity of direct control of processing.



% CPU
100
BATCH
UNIVAC 1106
UNIVAC 1100/42
RJE
DEMAND
73
74
75
76
77
78
79
YEAR
100
% RUNS
BATCH
UNIVAC 1106
UNIVAC 1100/42
50
DEMAND
RJE
73
74
75
76
77
78
79
YEAR

FIG. 3

This irreversible tendency was the cause and the consequence of the introduction into the market of peripherical high processing capacity offering both availability of applicative software, and easy interaction with main frames.

The passing from centralized to de-centralized processing is clearly illustrated by the two diagrams of fig. 3.

Both diagrams show a constant tendency to direct use of processing capacity by the user. This tendency is even more clear if an analysis is made of data regarding the percentage of runs started by RJE or time - sharing terminals in comparison with traditional batch.

Particularily difficult is to represent, from the numerical point of view, the datum expressing the evaluation of percentage of stand-alone processing capacity.

This is due to the fact that, within Italcantieri, installation of stand-alone computers was foreseen along with creation of completely new procedures or with transfer of activities not particularily important from the point of view of central computer utilization.

In line with the experience developed within Italcantieri the main reasons underlinyg these tendencies are:

Technical Factors

Generally, the performance of the systems is judged, from the user's point of view, on the basis of the number of transsactions per second and response time. Obviously, in this case, there is an increase in performance of many parallel centers as compared with the performance of only one main frame having the same global capacity. This is due to the higher probability to dispose of processing capacity particularily when the systems' utilization index is high.

A marriage between computers and communication means is at the basis of the most advanced system. The weak point of this union, however, is represented by the lines.

Both because of speed and reliability problems. The limitations relevant to the communication push to move the processing units near to the interested users.
The centralized systems, when exceeding determinate dimensions, cause heavy problems. Examples are the complex and sophisticated operating systems, of difficult maintenance, necessary to cope with different needs and with the remarkable complications from the operational point of view.

Economic Factors

The progress of the computer technology led to increase of performance associated with a decrease of costs.
Nowadays, the cost of the computer is, however, only a component, very often not the main one, of an extremely difficult choice.
For example, we notice that the costs of the means of communication, a basic component of all the present processing systems, show a limited trend towards reduction. Therefore we trie to economize them through a higher decentralization. Moreover the hardware investment, that is necessary today for new systems, is only a part of the needs. A big part of the investment is, infact, covered by the development costs of the applicative and basic software.

Specialization Factors

Many present applications are possible today thanks to the use of particularily specialized hardware with high specific performance that cannot surely be obtained from a single multipurpose computer.

Organizational Factors

The possibility of decentralization allows the construction of systems that are organically suitable to the various organizations with a high level of flexibility to cope with the diffe-

rent needs of the user, though respecting the co-ordination of the network.

Human Factors

The placing of the processing means in the different company departments is a decisive factor for the involvement of the user who is already prepared to manage the part of the system that directly interests his. functional area.

From what we have just said, it is clear that today the cost factor of the computer alone is not a decisive element of the DP choices.
Infact, to design a data processing system is today a complex operation resulting mainly from the matching of the users' needs and technological development:
At Italcantieri, the above mentioned factors have led to the installation (obviously besides main-frame) of the whole hardware range utilized for distributed data processing:

Data collection

Satellite graphic system

Data Entry / Data Capture

Dedicated interactive graphic system

Computers network

Compound satellite system for design and production.

5. FUTURE SOFTWARE PRODUCTS OF ITALCANTIERI

What has been explained up to now had the purpose of emphasizing and explaining the following three points:

I) Italcantieri had to devote particular care in designing its information system on account of its specific environmental difficulties (three yards located very far from one another

having different traditions and working methods).

II) Even-if a deeper analysis has been made of applicative software operating in the 'technical area, the intention was also to clarify how integration of application modules follows mainly vertical, not horizontal lines: integration in the systems, not integration among systems.

III) User's requests, hardware's development and acquisition of all D.P. advanced techniques (Data base, real-time, graphic interaction) direct the Company towards a new software generation.

Always within the field of applicative technical software, the bases of the new system can be identified as follows:

software and hardware modularity
modularity in I/O media
software transportability
processing capacity distribution
horizontal integration among systems.

Undoubtedly it can be stated that very modern firms could today be equipped with all D.P. instruments which cover more or less all company's fields.
What has not yet been achieved but should constitute an aim to be pursued is:

I) a simplification of logical flow of information which implies a consequent organizational improvement;

II) a considerable reduction of execution times of design and administrative operations;

III) a reduction in human resources necessary on account of constant increase in cost of personnel owing to the fact that, even when the number of people remains the same, there is a world tendency towards reduction of working hours.

In line with the principal aims which are pursued and with the main characteristics that the new system is required to have, Italcantieri has started - and as for hull design completely defined - the analysis and the functional specifications of two new systems:

AIDS (Advanced Interactive Design for Ships)

GAP (General Arrangement Plan).

which will unify all functions of systems now operating that were already described in details.

AIDS and GAP whose development will be, wherever possible, realized by successive parallel steps, will constitute one all-inclusive information system for design and Workshop documents and for preparation of bill of materials both for hull and outfitting design.

AIDS, the system which grants continuous definition and storage of all data contained in the classification drawings, will be formed by a series of independent modules connected to each other by a data base containing:

- the topological description of the hull structure that means storing of all logical relations among hull structure items in the data base;
- the assemblying sequence, explicitly or implicitly defined during design operations, that needs to automate the assemblying workshop documentation;
- the physical description of the structure for material ordering and handling.

The accurate up-dating of this information in the data base will allow transfer of a tridimensional model to GAP which is the module specifically programmed for piping design.

GAP, the flexibility and simplicity of hull design system (SCAFO DSI) utilization already allows Italcantieri to supply the office dealing

with detail design of machinery, piping and electrical plants arrangement, with all the drawings obtained as any section of the structure.

The new philosophy of the information system for design will allow a more rational utilization of information generated by hull detail design office.

This will be accomplished, thanks to the modularity foreseen both in hardware and software configurations, in two ways:

I) contemporary utilization of only one stand-alone station by hull and outfitting designers;

II) crossed utilization of data bases located on more then one specialized stand-alone station.

The GAP data base will have to be synchronized with the AIDS data base only at the level of physical and topological description of outfitting so that the designer can have continuous availability of the hull structure for which the system he is designing must be fitted.

The principal modules of the GAP system will allow:

definition of functional schemes;

topographical positioning of plants;

overall coordination of various plants;

realization of executive drawing and materials lists and flow.

6. DELIVERY PLAN FOR FIRST MODULES

Realization of the two AIDS and GAP systems, which will have to be complete with minor operative modules (I/O for structural analysis, hydrostatic and hydrodinamic calculations, electric system design, etc.), will require a considerable use of resources which will mostly leave their traditional working environment (main frame) in order to

develop products on minicomputers with intensive use of conversational graphical and alphanumerical techniques.

The delivery plan of the first modules is founded upon the two systems already in operation and present on t-he -market SCAF0 and GAIN.

The most interesting operative skills of the two systems can be summarized as follows:

SCAFO: easy and complete description of all hull internal structures, possibility to obtain any type of section (classification drawing), rich workshop documentation, ordering and material handling.

GAIN: part definition, part positioning, cutting path definition and drawing wording.

In line with the above mentioned purposes, the first deliveries for the AIDS system will deal with:

I) re-writing the whole SCAFO system for minicomputers with intensive use of graphical and alphanumerical interaction;

II) final preparation of the parts automatic generation module which, on the ground of the hull topological description, will allow elimination of boring traditional methods of part coding;

III) integration of GAIN system to data base supporting modules mentioned at point I and II, so that, in addition to possibility of automatic part generation, the GAIN part definition module, which also allows partial modification of parts (no matter how they were obtained), will be available;

IV) points I, II and III, whose completion is scheduled within the end of 1980 will also include a module for mesh generation and for I/O visualization in the structural analysis field.
Realization of this module will fully develop potentialities offered by the software mentioned at point II).
Following the policy of maximum processing de-centralization and considering that the detail design offices often need to make non

sophysticated structural calculations, suitable software tools will be implemented on the peripherical computers.

1980 will be mainly dedicated to the realization of what has been outlined above so as to enable the Company to enter the market with the first turn-key configurations which is specifically designed for shipbuilding industry, and not deriving from awward mixings of old and new technologies.

As for realization plan of GAP, relevant analysis is scheduled in the first months of 1980 and is to be followed by functional specifications and detail specifications.

In the meantime, as initial delivery of modules also in the outfitting field, conversion will be performed of the CASA system on minicomputer.

Without describing the foreseen hardware configurations in details, the Company has the availability of the most efficient 16 and 32 bits machines.

A P P E N D I X A

SCAFO system: a computer aided instrument in steel structure definition, generation and preparation

INTRODUCTION

The most crucial problem in shipbuilding is nowadays: how to tackle the reduced calendar time.

Hull process, from preliminary design to assembly, represents the most critical activity to reduce contract signing-to-delivery times.

Conventional methods even supported by some computer systems are, -not suitable to meet these demands because they are very often mortified by the prevalent geometric definition of the structure or because some activities need to be carried Out manually.

ITALCANTIERI had faced these problems since 1970. By that time some good software available in the market was bought and implemented, but it cove red only some application areas.
Hence the needs of extending the use of the computer, aimed to eliminate duplicated activities and at the same time to make it easy to perform parallel activities as much as possible.
Among the systems developed by ITC in technical applications a great deal of efforts has been devoted to develop the SCAF0 system, specific for definition, generation and preparation of hull structure.

MAIN GOALS ACHIEVED BY THE SYSTEM

When we set about to develop the system the many problems involved had been deeply analized.
It was clear that to be a successful system the following goals had to be reached:

1 - elimination of duplicated activities formerly performed both by the mould loft and by the detail design office as far as structu re definition, preparation and alterations are concerned;

2 - accomplishment of parallel activities in designing, definition and preparation of steel structure;

3 - full documentation for material handling and material processing at the workshop;

4 - full documentation for assembling, mounting, and erection of struc tural units;

5 - avoidance of redundant data over the different operational phases;

6 - hardware portability and easy links with other systems.

The foregoing points are achieved to day, thanks to the solution of the problems involved.

PHYLOSOPHY OF THE SYSTEM

SCAFO system is characterized by some basic concepts which are peculiar for the representation and logic definition of the steel structure by the aid of the computer.

These concepts, introduced in D-P., mainly refer to the conventional methods which are familiar to the designer or draftsmen.

They can be summarized as follows:

a - a steel structure is a collection of single structures each of which is a collection of connected details;

b - a single structure spatially refers to a geometric surface and it is bounded by the structures it is connected to;

c - a single structure consists of a panel, stiffening, completed by holes, seams and inner contours;

d - detail's of a structure as far as thickness of plates, scantling and orientation of profiles have to be fully ed univocally defined;

e - representation of the structure has to be performed by a general point of view and not orientated to a specific type of ship;

f - description of the structure has to be based on low-level standars which meet every orientation or direction of the details;

g - asymmetrical structure even in presence of an asymmetrical body plan has to be dealt with;

h - avoidance of data duplication as far as structure definition is concerned;

i - data stored have to be the minimum necessary, consisting of geometry (how the structure is arranged) and topology (where the structure is located);

j - geometry is separated from topology, so that when alteration occours in the delimiting structure, it will continuosly effect the relevant structure, simplifying maintenance in taking care of design alterations;

k - on the basis of the logic relationship between structures and the minimum geometric data, the actual boundaries are generated each time they are referred to, so that output assures tha last geometrical solution;

l - output support has to be a result of highy quality of calculation and complementary information must be supplied at any time;

m - prints and drawings have to be clear and easy to be interpreted so that they are legible both by technicians-and workers;

n - output has to be supplied according to the demand of end users, yard installation, and practical procedures.

PARALLEL ACTIVITIES

Although the concentration of mould loft activities with those of the technical office has produced a positive influence in calendar time, the most relevant results have been determined by the capability of parallel operations during the accomplishment of different tasks.

As you can see in fig. l, usually, in hull process man-power was distribuited in a longer time because of the conventional procedure.

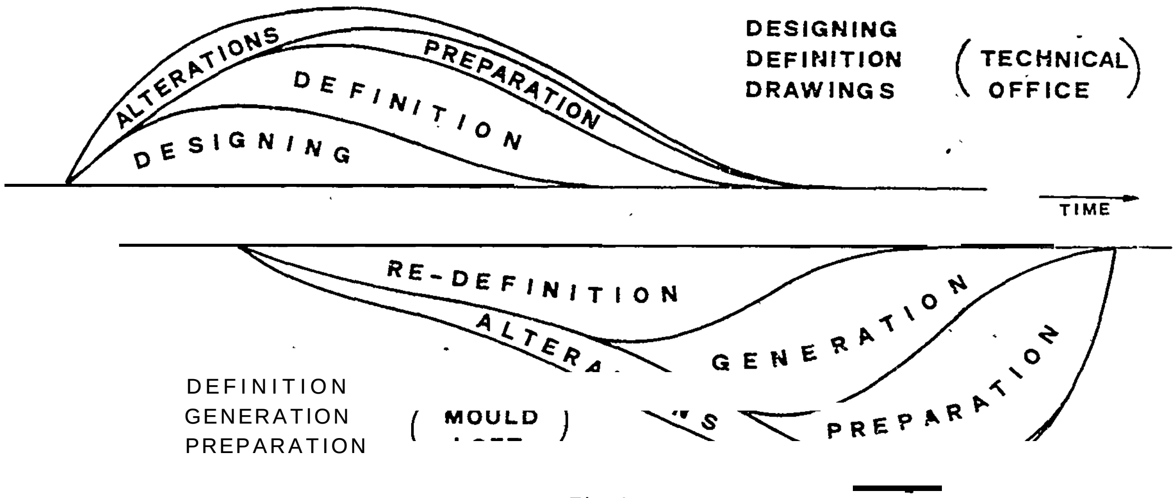


Fig.1

As a consequence there were two main phases which were almost duplicated by the mould loft. The first is structure definition and the second is work preparation. Besides alterations cause also duplicated work.

Today, thanks to the availability of adequate software, the procedure is different as you can see in fig. 2

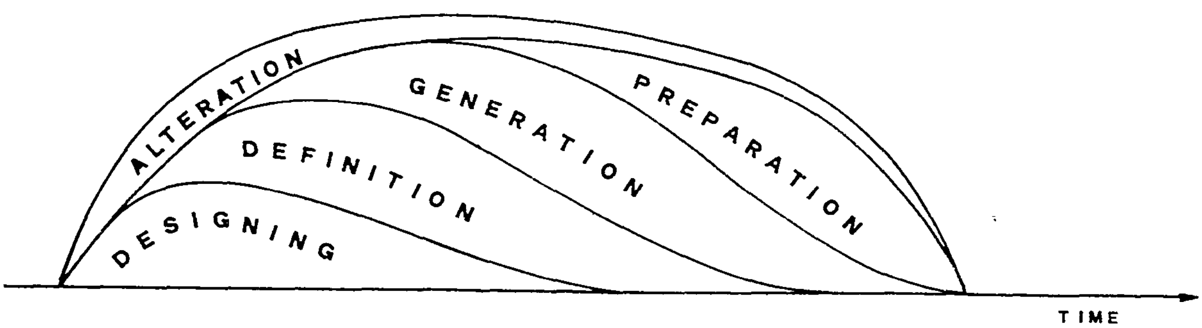


Fig.2

Apart from the relevant reduction, of duplicated work and bearing in mind the concepts described above (prevalent logic description of the structural model) many activities can now start in a phase which is advanced if compared with conventional methods.

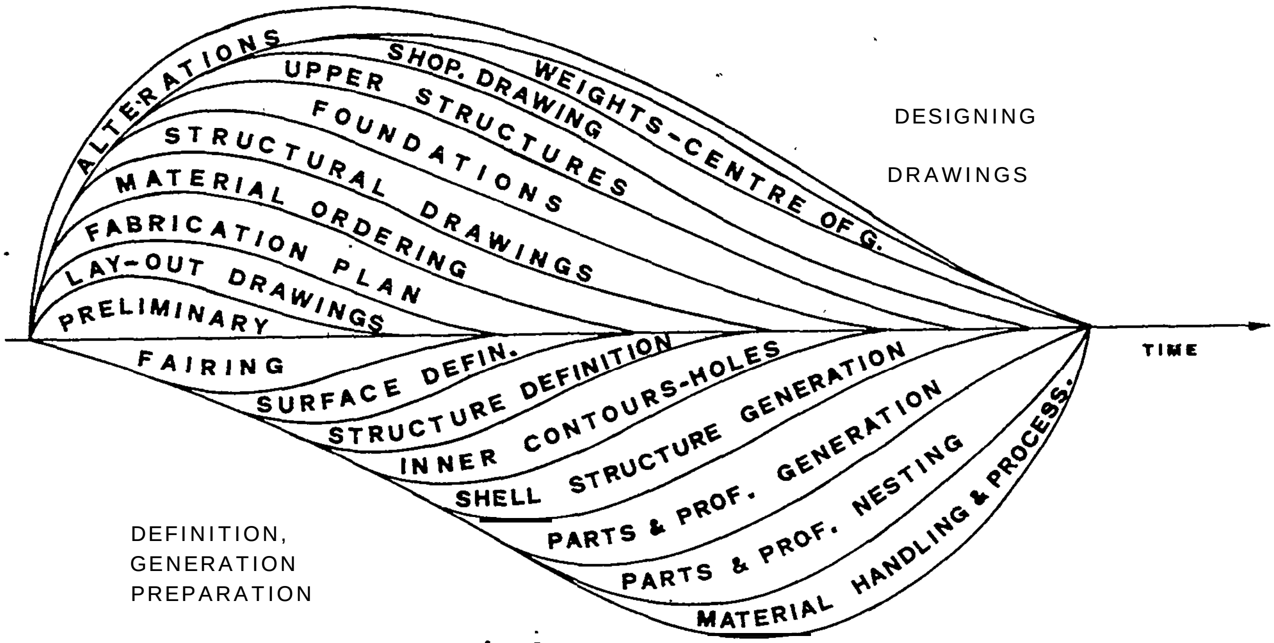


Fig.3

Structure definition can be initiated even though the actual body plan has not yet performed. This aspect is the most relevant factor because it influences, more or less, all the other activities.

BRIEF DESCRIPTION OF THE MODULES AND RELATED FUNCTIONS

Structure definition

Apart from body plan definition and loading, which are performed by FORAN or by AUTOKON BOF module, there are three modules of the system provided to handle and store the actual structure.

Transferring of longitudinal surfaces

The module can cope with any type of longitudinal surface either flat, curve, twisted, or a combination of the three geometrical conditions. Practically any typical surface can be determined and stored (unless it requires to be faired).
The module supplies the intersection points between the longitudinal surface boundaries and transversal plane in correspondence of transverse frames. Furthermore and for each transverse frame, ending points of every penetrating surface are printed.

Transferring of details at shell

The module stores the longitudinal seams and longitudinal profiles at shell.
It deals with any typical shell connection trace and for profiles the right web and face plate orientation can be indicated. Longitudinal structures connected to the shell are automatically included from previous loading.
Further to the above, details like bottom and side tangencies of body plan, are stored by this module.

Transferring of inner structure details

The module stores profiles, seams, minor structures and connections concerning inner structure. All profiles and seams are reduced into a few family types upon their prevalent arrangement.
They are furtherly simplified by the conventional way they are usually represented.
In general a detail belongs to a structural surface where it is mounted (profile) or it divides the panel (seam). Thus it follows the way of surface representation which is usually done over three conventional views:

- transversal view from aft to fore (web frames, transversal bulkheads, floors ecc.);
- longitudinal view from starboard side (longitudinal bulkheads, girders ecc.);
- longitudinal view from top (decks, tanktops, forecastle, etc.)

PRINTS AND TABLES

Another important peculiarity of the system concerns the significant offset tables of the whole structure representing its numerical image and an auxiliary medium in design activities.
These offsets are very useful both for checking purpose and for valid documentation of the various offices. They are mainly obtained during input operation, or separately whenever they are demanded.

Body plan offset

The module supplies, frame by frame, on offset of the body plan at any section of horizontal (WL) and vertical (BT) plane, including tangencies and kunckles.

Details offset

The module supplies significant information on the spatial extension and detail orientation of one or more groups of details belonging to one or more structural surfaces.

As far as profiles are concerned and during input operation the relative modules print some relevant production information like the raw or net lenght, scantling, type of ending (snipe, butt or overlapping).

DRAWING FUNCTIONS

A vital role in design phase and production is played by the different drawings representing the actual structure as a spatial object.
The system meets these demands since it is capable of furnishing a set of drawings which are comformed to the different representations of the structure at different levels of storing. Graphical outputs and their completion depend on the quantity of input which has been performed. What has to be pointed out is that the actual output does not depend on the wanted structure only, but also on the adjacent delimiting or penetrating structures which determine, in that very moment, the actual boundaries and the necessary contrast in the drawing.
Drawings can be obtained over the complete structure or part of it (windowing).
Graphical outputs can be conveyed on every kind of graphical devices. either flat and drum drawing machines or storage and refreshed CRT.

Body plan drawings

Drawings of body plan concerning transverse frames, waterlines, but toks, and other longitudinal curves are obtained during FORAN of BOF operation.
This module supplies drawings of body plan with additional waterlines or buttocks. They are useful for manual completion of body plan extremities (when they are not faired enough).

Shell structure drawings

The module expands and furnishes several levels of drawings of the body plan completed with seams, profiles and connected structures.
In particular it furnishes:
- shell expansion plan, and connected structures
- shell expansion plan including butts and seams only
- transversal body plan comprehensive of traces of the internal structure
- transversal body plan comprehensive of longitudinals, seams and butts traces at shell including profiles section; orientation and tangencies.

Inner structure drawings

The whole internal structure is graphically represented by this module which is capable of generating drawings over the various extensions and conventional views of the hull.

INTERNAL STRUCTURE' GENERATION

About sixty per cent of parts of the internal structure are today generated by ALKON module, supported by ALKON norms and by new ALKON commands developed by ITC.
The remaining parts and all the, profiles are generated by the output modules of the system or manually (rectangular plates).

Collar plate generation

The module generates the collar plates over the structure they are later associated to.
Production data as bevels, weight, minimum scrap of material, are also furnished.

Simple plate generation

Most of the panels plates are often defined as a rectangular or as a simple poligonous. They are usually generated manually (repetitive pieces) or by means of this module which works over the seams, inner contours, and simple derived contours handled by the system.

Profiles generation

The module expands and transfers element information and its relation into an appropriate file.
It operates over the information stored in a previous phase.
Missing information can be associated in this phase to complete an existing profile or to generate a new one.

SHELL STRUCTURE GENERATION

This operation is performed by three modules including the one which supplies templates for rolling and bending purposes.

Shell plates expansion

The module expands any type of shell plates (apart from the very shaped plates situated at the extremities) either they are simple, double, or partially curved or they are longitudinally and vertically arranged. They are expanded with a new method (mosaic method) which assures the highest precision.
Output of this module can be Summariezed as follows:

- expansion calculation takes bending effect and welding shrinkage into account;
- to be aware of correctness the User is warned of the results of expansion and he can influence such results by further processing of not satisfying output;

- paper tape for 2 or 3-axis flame cutting machines including punch marking or flame tracing contour;
- rolling line or tangency are part of marking contour;
- cheching data to be used before or after the plate is rolled or bended;
- minimum rectangular plate and data for evaluation of bending and heating.

Shell profiles expansion

The module expands either longitudinal frames or transverse frames at shell. Paper tape for drawing and relevant production information are supplied as described below.

- Scantling of profiles are fetched from previous storing and expansion is computed over the barycentric line.
- Repetition makes it easy to fill up forms.
- Notches and holes can be included.
- Butts or endings in standard version or upon user's request.
- Bending evaluation, marking and hand-cutting information.
- Web plates which have to be cut from plates are transferred into the AUTOKON Data Base for further nesting.
- Bending table is automatically obtained for a group of profiles and constitutes document A9 furtherly described.

Templates of shell structure

Templates for shell structure bending are built over the information supplied by this module.
Such information is given either in the form of tables or paper tape for templates drawing.

SHELL STRUCTURE FABRICATION AND OUTFITTING

Shell block erection

The module supplies several technical and production information which are essential during the delicate phase of shell structure erection.
Panel can be arranged prevalently horizontally or angles of rotation can be forced.
Going through the entire phase of structure erection the following information are supplied:

- actual drawing of the panel and traces of the internal structure;
- boundaries of the panel referred to the platform;
- corners of shell plates spatially referred;-
- panel marking and checking data, mounting angle of profiles;
- mounting angle either for transversal and longitudinal structures;
- significant data to check boundaries and structures after welding.

Painting lines table

The module computes and supplies information to trace painting lines along the shell surface.
For each T-frame both height from base line and arclength from the nearest seam are supplied.

Draught Marks

The module expands draught mark numbers and supplies drawing of developed numbers and production information:
- four types of draught marks are provided;
- cutting and welding contours;
- templates to mark levels of numbers.

WORKSHOP DOCUMENTATION

The documents concerning one or more units are fundamentally grouped in:
A) documents for processing raw and finished materials
B) documents for handling raw and finished materials.

General basic list

All information concerning a lot and distributed on the various out puts, derives mainly from a general basic list, whose programs are integrated in the hull system.
Lot by lot, unit by unit, and subassembly by subassembly, all consisting parts are taken into consideration.
The output is utilized in a successive phase to obtain the workshop documentation necessary for work performance.

Most significant aspects of some documents, automatically supplied by the system

Document type "A"

Document "A1" - It is the document which is attached to the punched tape for the N.C. cutting machines. It shows all indications necessary for the operator and the marker of the cut parts. It represents the graphic result of the part nesting operations. Representation is made on 1:20 scale.
Document "A2" - It represents the result of the "N.C." cutting operations concerning the lot.
Lot by lot and for each cutting scheme the document gives relevant information.
Basing on such data, we plan the work loads of the N.C. cutting machines.

Document "A3" - It represents the cutting scheme for the parallel cutting machines.
Document "A4" - Similar to document "A3", it is used to obtain flat bars from plates.
Document "A5" - It represents the cutting scheme for pantograph and shears.
Document "A6" - It concerns the schemes for manual marking of hole notches on profiles.
Document "A7" - For description of bending or curving operations subsequent to plate marking.
The document is used by the pressing machine, rolling machine, and flanging machine.
Document "A8" - It concerns manual marking, cutting and handling of profiles. This document is obtained as output of program "Hull general basic list"; the input data are fetched from AUTOKON Data Base and handled by the program.
Document "A9" - This document gives the characteristics of the profile pieces to bent it, with full information for its completion.
Document "A12" - It represents the final document of the "cutting scheme for profile " made by computer.
Document "Al5" - This is the basic document for assembly purpose during prefabrication of the parts processed in workshop.
Being a drawing document it is manually completed.

Document type "B"

Document "Bl" - This is the program for steel plates feeding subdivided in:
- plates intended for N.C. cutting
- plates of shell intended for N.C. cutting
- plates intended for parallel cutting
- plates to be cut by pantograph
- plates to be manually marked.

The main information given are:
- lot number
- cutting scheme number
- raw material
- painting
- sizes of raw piece to be cut
- material quality.

Document "B2" - This is the program for profiles, feeding the workshop subdivided in:
- profiles to be marked and cut
- profiles to be directly dispatched to small prefabrication
- profiles to be directly dispatched to big prefabrication-
- profiles to be bent and then intended for big prefabrication
- profiles to be bent and then intended for small prefabrication.

Document "B3". - This output shows the detail of the pieces obtained from plates described under "Bl". It indicates for each cutting scheme:

- pieces to be obtained
- subsequent processing work, if any
- working area, block and subassembly.

Please note that "A8" has the same function as "B3" for profiles.

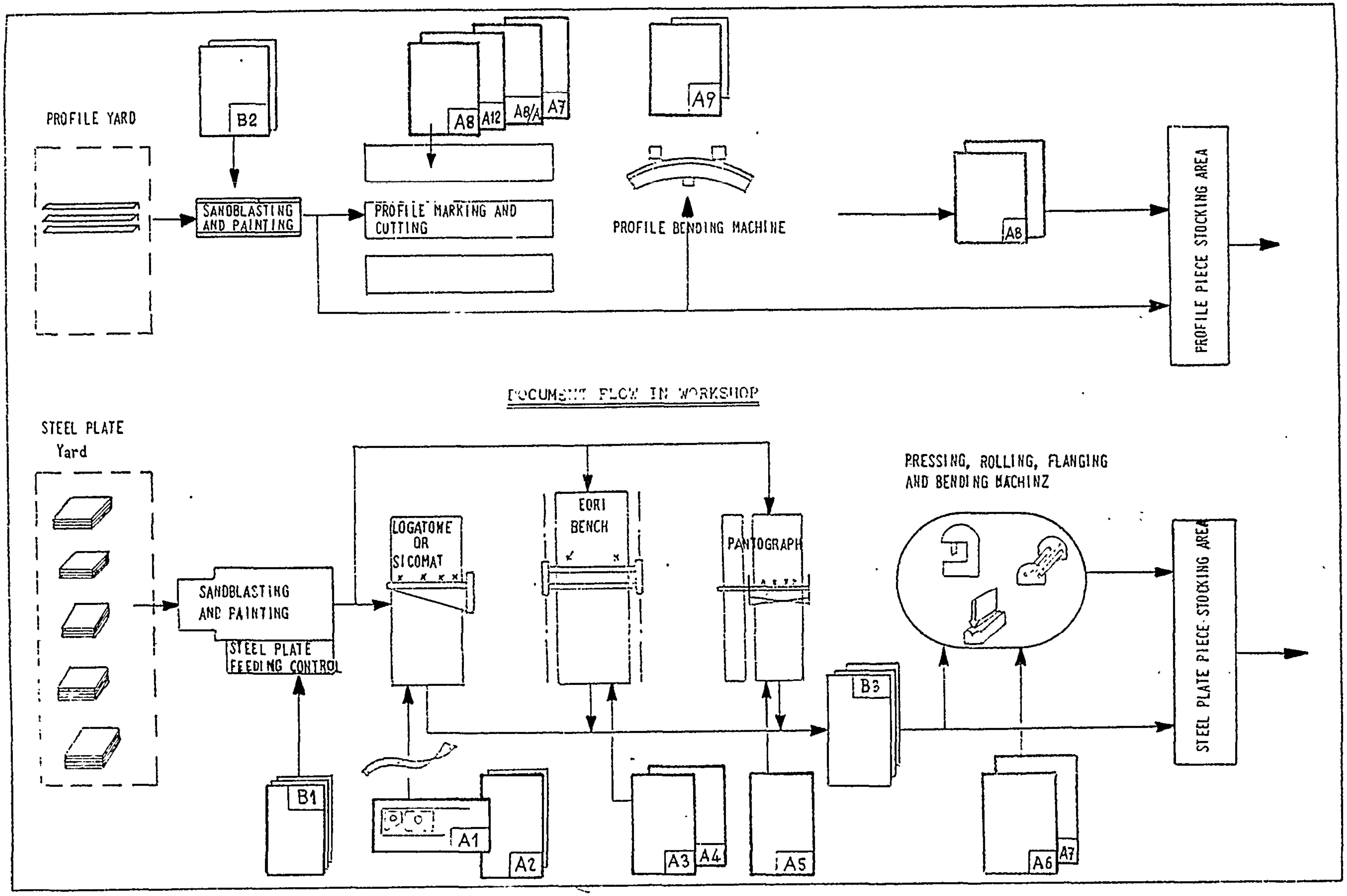
Document "B4" - It integrates "A15", as it gives the composition and the weight of the represented subassemblies.

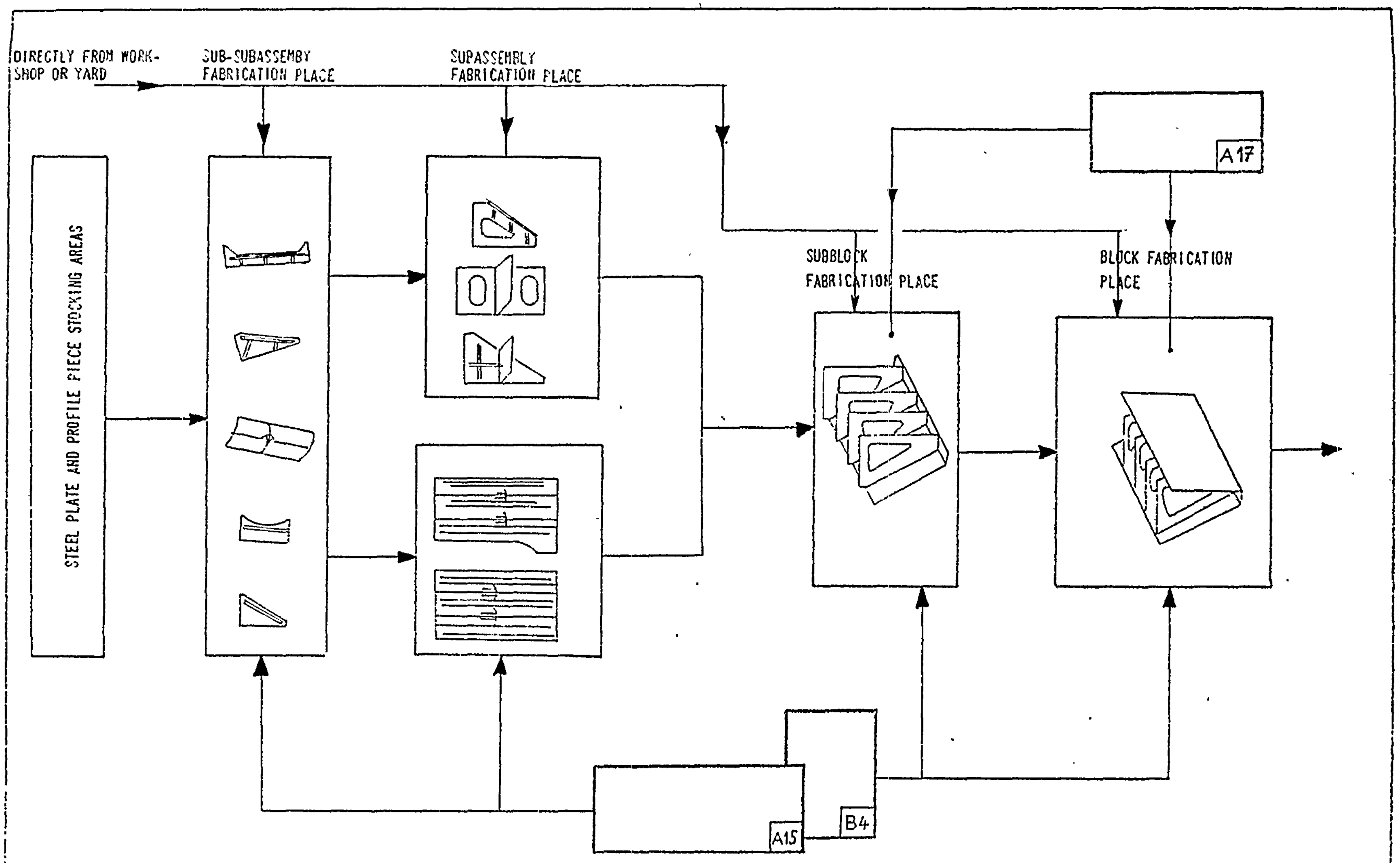
The following figures show the manufacturing phases where above documents are utilized.

REFERENCES

R. Di Luca, E. Bais: SCAFO, a CAD and CAM integrated system, from basic design to assembly.

ICCAS '79.


PROFILE YARD
B2
A8
A12
A8/A
A7
A9
SANDBLASTING AND PAINTING
PROFILE MARKING AND CUTTING
PROFILE BENDING MACHINE
A8
PROFILE PIECE STOCKING AREA
DOCUMENT FLOW IN WORKSHOP
STEEL PLATE Yard
SANDBLASTING AND PAINTING
STEEL PLATE FEEDING CONTROL
LOGATOME OR SICOMAT
EORI BENCH
PANTOGRAPH
PRESSING, ROLLING, FLANGING AND BENDING MACHINZ
B3
STEEL PLATE PIECE STOCKING AREA
B1
A1
A2
A3
A4
A5
A6
A7



DOCUMENT FLOW TO PREFABRICATION SHOP

0006

INCREASED SHIPBUILDING PRODUCTIVITY THROUGH PRODUCTION ENGINEERING

Frank H. Rack
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Mr. Rack is currently President of Shipbuilding Consultants Inc. He is a graduate of U.S. Merchant Marine Academy at Kings Point with a degree in marine engineering. His past experience includes 17 years in various positions with the Electric Boat and Quincy Shipbuilding Divisions at General Dynamics, and a year and a half with Todd Shipyards Corporation. Mr. Rack also served 2 years as an officer in the U.S. Navy.

GOOD MORNING:

I was especially pleased to accept the offer to speak on this subject having devoted my career as a shipbuilder and now as a consultant to productivity problems.

Before I discuss the details of how production engineering can help a shipyard, I thought it may be worthwhile to review the present state of American Shipbuilding:

First, we have the "Big Soys": These are the shipyards who build commercial and government large ocean-going vessels. All but one are part of a conglomerate. Over the past 10 to 20 years they have modernized their shipyards, introduced computerized lofting and NC burning, along with a sophisticated production planning and control system. Production Engineering can help these shipyards but the degree of improvement is limited. The fate of the "Big Soys" lies in the hands of the Government. Government policy for private shipbuilding and for the US Navy will determine how many of these shipyards will survive or close. The amount of diversification will be a major element as to who will survive or who will fall.

Next, we have the offshore petroleum and gas industry. If our country is to survive this has to be a growing industry. My experience is this field is limited and therefore, I will not comment on its future except to say it looks good.

The third area, and the one which I have had the most intimate contact with during the last five years, is the Inland Water Ways, Coastal and the Great Lakes Shipbuilders. The latest MarAd study

predicts waterways cargo will double by year 2000. The number of hopper, tank, deck and other types of barges presently operating on American rivers and coasts exceed 20,000. The expected life of these barges is around 20 years. Therefore, you can equate the numbers to a potential need of around 1500 barges in 1980, and growing to a potential need of 3000 barges per year by the year 2000. Supporting tow boat construction and repair services will also be required.

Looking at the "numbers" I think it is safe to say that this area of shipbuilding can look forward to some very good years.

Major productivity improvement potential exists in the following shipyard areas:

1. Organization (People and Structure)
2. Engineering
3. Planning and Production Control
4. Material Handling and Control
5. Production Engineering

The first four items are necessary prerequisites for a productive shipyard operation.

ORGANIZATION

Good people are the most important element of any organization. They benefit and are able to operate more efficiently when the organizational structure is clearly defined as to functional responsibilities and duties. A good management information system also improves the overall effectiveness of these good people.

The trained shipyard worker has become harder to hire and retain. This trend is expected to continue, therefore better training and retention

programs must be developed. The threat of losing skilled workers to construction and other higher paying Industries will continue. The answer is to increase productivity and develop equipment, systems, procedures and methods that reduce the man-hours required to build ships.

ENGINEERING

The key to a successful start of a shipbuilding contract is how well the Engineering department performs. If Engineering can issue complete approved plans and material requisitions on schedule the first hurdle is passed. However many times Engineering is not allowed enough time in the schedule and the result is that preliminary plans or incomplete plans are released to the yard. Many yards make the mistake of working to these preliminary or incomplete plans in the hope that when the "clean" plan is issued they will have minimum rework which is usually not the case. The result of this action is that:

a) Production man-hours used for installation and then ripout results in no physical progress.

b) Material costs have increased

C) All paperwork had to be redone and reissued

d) Work is more delinquent to schedule than if it was not performed.

e) Supervision and worker morale suffer.

With the present great need for trained shipyard workers the best course of action has to be <u>not to work</u> an area where the plans are not "clean" and for management to expedite resolution of problem areas.

Shipyards that have their own Engineering departments have the advantage of better control of their destiny than those that have to

use a design agent and computerized lofting services. Greater engineering lead time is required and changes have a greater schedule impact when using design agents. In addition the design agent usually is not aware of shipyard equipment, production 'methods and operating procedures.

My experience has shown reductions of over 25% in production man-hours as a result of a detail production engineering review of engineering drawings and improvements in production methods and operating procedures. Not only do you get the benefits of reduced man-hours but you can improve your performance to schedules. This area will be discussed later in more detail.

PLANNING AND PRODUCTION CONTROL

We have conducted many surveys in shipyards that are involved in this industry and have found that the Planning and Production Control system (PPC) used in these shipyards vary greatly. Reference (A) is an excellent text on production oriented planning. In general, except for the major shipyards much can be done to improve the PPC systems; it would be very cost effective if shipyards had an objective outsider like Shipbuilding Consultants Inc. (SCI) review their PPC operations to determine its effectiveness.

MATERIALS HANDLING AND CONTROL

To maintain productivity, materials must be at the job site on time and located within easy reach of the worker. Complete work must be moved to its next destination quickly to minimize delays or relocation of workers. An effective material handling and control system adds greatly to improve productivity.

PRODUCTION ENGINEERING

The remainder of this speech will. be devoted to production engineering. I am convinced that if a shipyard is operating with good people and has good control over Engineering, Planning and Production Control and Materials, it will be a successful shipyard. However, the following is a more common situation:

It is customary for the shipyard before contract award to establish various schedules which indicate the dates by which they plan to accomplish the various requirements leading to delivery of the vessel by or before contract date. All too often, based on the shipyard's "need" for the contract, the schedule is what I term "forced". One or more of the schedule events cannot be accomplished to meet the schedule presented to the owner. Either engineering, materials or production, or all three functions are being "forced" by top management to meet these schedules when in fact they don't know how they will accomplish their responsibilities.

Shipyard management should "test" all schedules before committing to an owner. The "test" should be an objective in depth review of the shipyard's resources as they pertain to meeting existing and pending contract requirements including factoring into the review other requirements or possibilities that may affect performance. Specific items that should be inlcuded in this review are:

a) Engineering resources to meet scheduled approval plan issue dates. (not preliminary releases)

b) Engineering resources to meet purchase specification and material requisition schedule dates.

c) Engineering resources to handle changes and shipyard, liaison problems.

d) Material long lead items delivery to support in yard schedule dates.

e) Production manning resources by department to meet all, in-house contract requirements.

f) Production performance evaluation which may change number of men required by specific trades to meet all contract require;, ments.

g) Evaluation of labor contracts including major equipment suppliers as to possible impact.

h) Facilities review of equipment, lay down space, lifting requirements, throughput, maintenance and possible breakdown of, required equipment, etc.

j) Other items not limited to potential weather conditions (cold, flood, etc.) turnover, training, labor pool, local politics and industry trends.

Upon completion of this objective review, top management will have a listing of the "hard spots" which can effect meeting contract requirements. The problems will have been identified and a corrective action plan can then be developed to ensure solving of the problems and meeting cost and delivery requirements.

The necessary corrective action can be attained through production engineering to reduce man-hours and costs and reduce schedule times to meet contract deliveries.

I'm sure that you all have a multitude of opinions as to the definition of production engineering. Mine is a "catch all" definition:

Production Engineering is:

Any effort applied to existing operations, methods, and procedures that results in a reduction in man-hours, material savings or improved schedules.

I have found that the best approach to take in conducting a production engineering survey in a ship,yard to attain the fastest gains in productivity and be least expensive is as follows:

1) Conduct an in-depth review of all functional departments to determine how they operate and support the manufacturing process leading to delivery of the product.
2) Identify the critical path schedule and magnitude of man-hours and cost expenditures relating to schedule key events.
3) Conduct a production engineering analysis of 1 and'2 to identify areas for improvement.
4) Formulate recommendations and prepare justifications and estimate of results to obtain approval of recommendations.
5) Implement recommendations through in-house personnel and follow up on progress.

Let me give some representative examples of what we have found during our various surveys:

Critical Path

The critical path in ship, boat, or barge construction usually is from keel to launch and for self-propelled vessels also from launch to delivery. The total elapsed time and degree of manning applied usually determines how performance will be to budget.

Anything that can be done to shorten the elapsed time has a greater effect than just that of the specific item savings. This is because approximately 20 to 30% of the man-hours being expended during these periods are time related i.e.: supervision, crane operators, cleaners, temporary services, security, material men etc. If the one specific item reduced the schedule by one week you would also get a one week reduction in all time related charges.

Production engineering items that we have implemented with great success in shortening the critical path are:

1) Planning and scheduling work upstream and/or in parallel to remove it from the critical path.
2) Erection of larger hull sections
3) Utilizing better jigs and fixtures
4) Improved manning and manpower assignments
5) More automative welding equipment or better processes.
6) Preoutfitting

Steel Subassembly and Main Assembly

Steel Subassembly and Main Assembly work also requires long elapsed schedule time and many production man-hours. The facility required to efficiently perform this type of work usually consists of covered high bay buildings with heavy lift capabilities. Many yards, however, are forced to perform this work outside. The common error made is in the type of work that is performed in these work areas. All to often you will see such items as layout, fitting, tacking and welding of stiffeners and brackets to plates or panels and also stiffeners being put on webs.

The time required to perform this type of work ties up these valuable facilities. It also requires that you have more floor space than is necessary or forces work outdoors. This type of work does not require high bays with heavy lift capability and therefore should be scheduled to be performed elsewhere.

The following items will improve productivity of the transferred work:

1. Numerical control burning and marking
2. Plate stiffening
3. Webb stiffening
4. Panel stiffening
5. One sided welding up through 5/8" thickness
6. Magnetic bed and welding gantries
7. Special jigs and fixtures
8. Shape line

Production engineering evaluations and justifications Will be required for all of the above items.

Other Areas

There are many other areas where production engineering can increase productivity. Starting in engineering a complete review of the design for changes that will help production is always advisable such items as:

1. Restraking for plate stiffening
2. Part numbering
3. Part standardization
4. Modular breakdowns
5. Access
6. Staging

In Production, operating procedures and work methods should be reviewed and improved. Evaluations of covered vs. open work areas sometimes reveals areas of improvements. Organization of work areas to improve the production flow and doing as much outfitting on land rather than in the water will prove to be' very beneficial.

This can go on and on, however I believe that I have given you a good idea as to the activities that can be affected by production engineering. Ideally people in this area should be shipbuilders with experience in several yards with an industrial engineer or equivalent background. Properly motivated and utilized, personnel in this activity I can say with considerable experience will in every shipyard increase productivity through improved methods, procedures and operating systems. This, coupled with an efficient PPC system, a good material handling and control system, good sound practical' engineering and an efficient organizational structure then the shipyard is ready for the "icing on the cake."

Work Measurement

I am happy to see that five of our major shipyards are participating in a MarAd funded program to establish standards for many of the shipyard production trades. At Bath Iron Works Corporation we participated in establishing engineering standards for use in steel fabrication shop scheduling and loading, the pilot program that led to present efforts. I quote from Reference (A), "Before engineered standards were used the completion of units averaged 3.2 weeks late. For the three month period in which engineered standards were used the averaged time was reduced to zero weeks and a reduction of 21% in man-hours-per-ton beyond normal learning effects was projected."

These improvements I feel were attained more from detail scheduling of the work areas and improvement in operating methods and procedures than from establishing standards. I have visited many shipyards and observed their production operations and truly feel that most american shipyards are not ready for detail standards. Standards should be developed based on the best methods and procedures. In most yards much can be done to improve the production methods and procedures.

We are putting the "cart before the horse" The improvements that can be made through production engineering in the areas I have discussed today far outweigh those that will result from work measurement, time studies and standards. The best answer for a shipyard is to reduce man-hours and schedule span times by initiating a detailed production engineering survey of existing operations. My company's brochure is up front here describing the services we offer in these areas. I will be pleased to answer any questions and I, Thank You.

REFERENCES

Ref. (A) A Manual On Planning and Production Control for Shipyard Use. MarAd and Bath Iron Works Corp.

DESIGN FOR PRODUCTION

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Mr. MacDougall is presently Director of the development engineering and consulting firm, A&P Appledore Limited. He has had management training from both Glasgow University and the Administrative Staff College at Henley on Thames; is a chartered engineer and member of the Royal Institute of Naval Architects.

Mr. MacDougall has a number of years experience in ship design, ship construction management, production planning and control, corporate planning, and as controller of costs and methods at the British Shipbuilders Headquarters.

David Carss
Senior Consultant
A&P Appledore Limited
London, England

Mr. Carss is a Senior Consultant with A&P Appledore Limited and is a member of the company's team engaged in ship producibility studies, with responsibility for outfit engineering aspects.

A: BACKGROUND TO DESIGN FOR PRODUCTION

I. The Integration of Ship Design and Production

The traditional role of the Ship Designer is the preparation of an overall design of vessel which will have a performance satisfying the owner's Statement of Requirements.

The concept of Design for Production, however, requires that, in satisfying the Statement of Requirement, the Ship Designer should also give attention to ease of production. This suggests, therefore, two aspects of the overall design, namely:

design for performance
design for production

and there are others, not considered here, such as design for repair and maintenance, and ergonomic design.

Clearly, there will be areas of inter-action and the role of the Ship Designer could be seen in this context as one of arbiter, having the ultimate responsibility of deciding whether performance or production considerations should take precedence in any particular case or the nature of the compromise to be reached.

Many of the procedures necessary involve consideration of every feature of the ship from the overall viewpoint. Any tendency to divide design into the traditional elements of steelwork, outfit, engineering and piping would provide a totally inadequate basis upon

which to base effective Design for Production.' Consideration of the inter-relationship between one element and another is essential and the term Integrated Design is used to define this concept.

2. Organisation of the Design for Production Function

The extension of the design process to include a design for production function has the following primary objectives:

To produce a design which represents an acceptable comprimise between the demands of performance and production.

To ensure that all design features are compatible with known characteristics of shipyard facilities.

To apply individual Design for Production procedures in so far as they are relevant to the particular shipyard where a vessel is to be built.

To co-ordinate the inter-relationship between the engineering and outfitting work with the structural work, in order to create a fully integrated design.

Examples of the detailed work necessary are as follows:

Hull Geometry and Scantling

The definition of hull shape and structural components should be considered together with the breakdown of the hull into blocks and modules. In addition, consideration should be given to the rationalisation of the scantlings of plates and sections. The relationship between unit/block length and maximum material length is a vital one.

Structural Planning

Concurrently with the above, block and unit breakdowns should be related to shipyard facilities ensuring that the natural breakdown does not conflict with what is practical.

Engineering

The definition of principal machinery and machinery arrangement related to block and unit breakdown. Machinery weights to be allocated to appropriate blocks or units. Principal pipe and cable routes to be defined within machinery spaces.

Pipework

The various piped services within the double bottom to be defined with particular reference to the entry point into the engine room and the effectiveness of a duct keel as a pipe tunnel to be determined. Standard pipe lengths should be examined in relation to block or unit lengths.

3. The Question of Lead Time

Shipyards in Europe, Scandinavia and Japan have traditionally sub-divided the delivery time of ships by creating an extensive period prior to starting production for detailed design, planning and production engineering. This has allowed the greater development of Design for Production techniques and procedures. A short ship production cycle time, characteristic of those countries, itself requires a long lead time to carry out the necessary technical work to allow cycle times to be reduced. The overall delivery period has not necessarily been significantly reduced for individual ships but has been so for series of ships.

4. Improved Producibilitv

The process of improving productivity can be considered under the following headings:

- Designing work content out of the ship design
- Improving the efficiency of production processes
- Making better use of working hours
- Reducing ship production cycle times.

Design for Production is primarily concerned with the first and last categories but Design for Production procedures have benefits, direct or indirect, in the other categories. If productivity is to be increased, the question is not one of whether to implement Design for Production but rather how to implement and to what extent. The traditionally shorter lead times in US shipyards may therefore present a problem until benefits in terms of shorter production cycle times accrue.

Other procedures, particularly equipment and ship module techniques, do require an investment both in time and manpower to realise the potential benefits. In these cases, it is necessary for each individual shipyard to review its own position and define the extent of implementation.

5. Aspects of Production Affected by Design

The effective application of design for production should result in the following:

A rationalised use of materials.

A reduction in work content, including material handling.

A reduction in the cycle time necessary for ship production.

The categories under which a particular procedure is considered to have the greatest effect are listed below. The list should provide some guidance as to the procedures to be adopted in relation to the limits set by a particular production situation.

Rationalised Use of Materials

Rationalised accommodation layout
Grouping and interface simplication
Attention to design details
Attention to pipework details

Reduction in Work Content

Simplified hull form

Continuity of internal surfaces

Effective use of surfaces and spaces

Separation of functional spaces

Standard approach to machinery space layout

Acceptable environmental working conditions

Attention to steelwork design details

Attention to welding design details.

Reduction in Cycle Time

Series production of cargo spaces

Use of equipment modules

Use of ship modules

.Attention to unit and block breakdown

Consideration of ship construction methods.

B: THE METHODOLOGY OF DESIGN FOR PRODUCTION

I. Introduction

The development of improved producibility must parallel the design development work and will influence it at every stage. Aspects of design for production are also capable of further development during the production phase but even at contract design stage, attention should be given both to achieving a generally production kindly design and allowing and encouraging further production engineering work in a post contract context.

2. Simplification of Hull Form

To the greatest extent possible within the dictates of the performance specification, the lines of a ship should be formed from a combination of simple shapes so that the work content inherent in production of the structure forming the hull surface may be reduced. The basic concept is a performed order of increasing complexity:

straight lines or flat surfaces
surfaces having curvature in one plane only
surfaces having curvature in two planes.

Although the lines of the ship are often quite tightly defined, small changes not significantly affecting performance may be possible to allow improved producibility (Ref. fig. 1).

3. Continuity of Internal Surfaces

Where possible and desirable, the internal volume of the hull should be divided so as to provide continuity of surfaces in the horizontal, longitudinal and transverse planes. Surfaces which may be either part of the main structure or a local element should be within the principal planes and not angled to them. Steps, cranks, recesses and other forms of discontinuity should be avoided so far as possible unless required to simplify end connections or because of specific authority (Ref. fig '2).

The internal spatial configuration will generally be easier to influence than the hull form and it is important to fully investigate this aspect to allow further work to be done in the area of block breakdown and advanced outfitting.

4. Effective Use of Surfaces and spaces

Platforms and bulkheads should be so positioned that each performs the maximum number of functions which may be assigned to it. By objective consideration of these functions, simplification of layout, particularly in accommodation spaces, may be achieved leading to savings in material and simplified access for welding and painting

5. Separation of Functional Spaces

Examination of the machinery space of many types of merchant ship reveals a number of functional divisions under which any design may be considered. The concept may be fully exploited by the development

of a standardised design approach to the machinery space allowing easier development of the design for alternative propulsion systems. In those shipyards possessing the necessary facilities, the concept should be extended to allow the production of each functional division to be carried out in the form of one or more ship modules.

Examples of the possible functional separation are:-

Propulsion
Auxiliary services
Ancillary services
Exhaust removal
Accommodation and ship control.
(Ref. fig 3)

6. Grouping and Interface Simplification

Well defined routes for systems should be established at an early stage of the design, both to simplify installation procedures and to establish the physical aspects of interfacing requirements. Systematic grouping should be adopted to the maximum possible extent.

Typical applications are:

Fuel oil, bilge and ballast lines running fore and aft within the double bottom, possibly inside a duct keel.

Fuel oil, salt water, fresh water, air, steam, hydraulics and electrics running at various levels in the machinery space.

Vertical connecting runs within the machinery space and from the machinery space to the accommodation block.

The establishment, for example, of pipe passages provides the possibility of maximum use of standard, straight lengths of pipe. These can be arranged in the form of large pipework assemblies, with the pipe supports designed to permit both workshop manufacture of the assembly and, due to inherent rigidity, transportation to the ship without damage to the joint seals (Ref. fig 4).

7. Rationalised Accommodation Layout

The shape of accommodation blocks should be simple with maximum use of straight lines and flat surfaces for boundaries and internal division. Rooms and contents should be standardised as far as possible (Ref. fig 5).

8. Series Production of Cargo Spaces

Wherever possible, the overall arrangement of the design should facilitate the division of the cargo length into equal length units/blocks which are the most appropriate for the facilities of any given shipyard.

9. Use of Equipment Modules

Some shipyards will have sufficient facilities to allow groups of auxiliaries to be formed into equipment modules by mounting them on a common base plate. Equipment Modules should be assembled in a workshop remote from the building berth. Although not all shipyards will have the

appropriate facilities, the development of the design should encourage the subsequent application of this concept,

I0. Use of Ship Modules

Blocks equipped with a number of outfit assemblies or equipment modules, referred to as Ship Modules, are applicable to any part of the ship where multiple trades are required to manufacture and equip. Ship modules should be assembled in a work shop remote from the building berth. The application of ship modules is assisted by the functional layout of the machinery spaces. Again, fewer shipyards will have the necessary facilities but the ship design should allow for their subsequent development (Ref. fig 6).

II. Consideration of Design Details

Design detailing procedures as influenced by design for production techniques conveniently divide themselves into the following major areas:-

- Steelwork design
- Unit and block breakdown
- Pipework design
- Electrical and other outfit systems
- Ship construction
- Welding design.

At this level, recommended design details can not be of universal application. The extent to which procedures can be adopted in a particular shipyard is dependent on the level of technology appropriate to the

shipyard, A number of general themes do, however, manifest themselves and will be applied. For example, the following list is illustrative but not exhaustive:

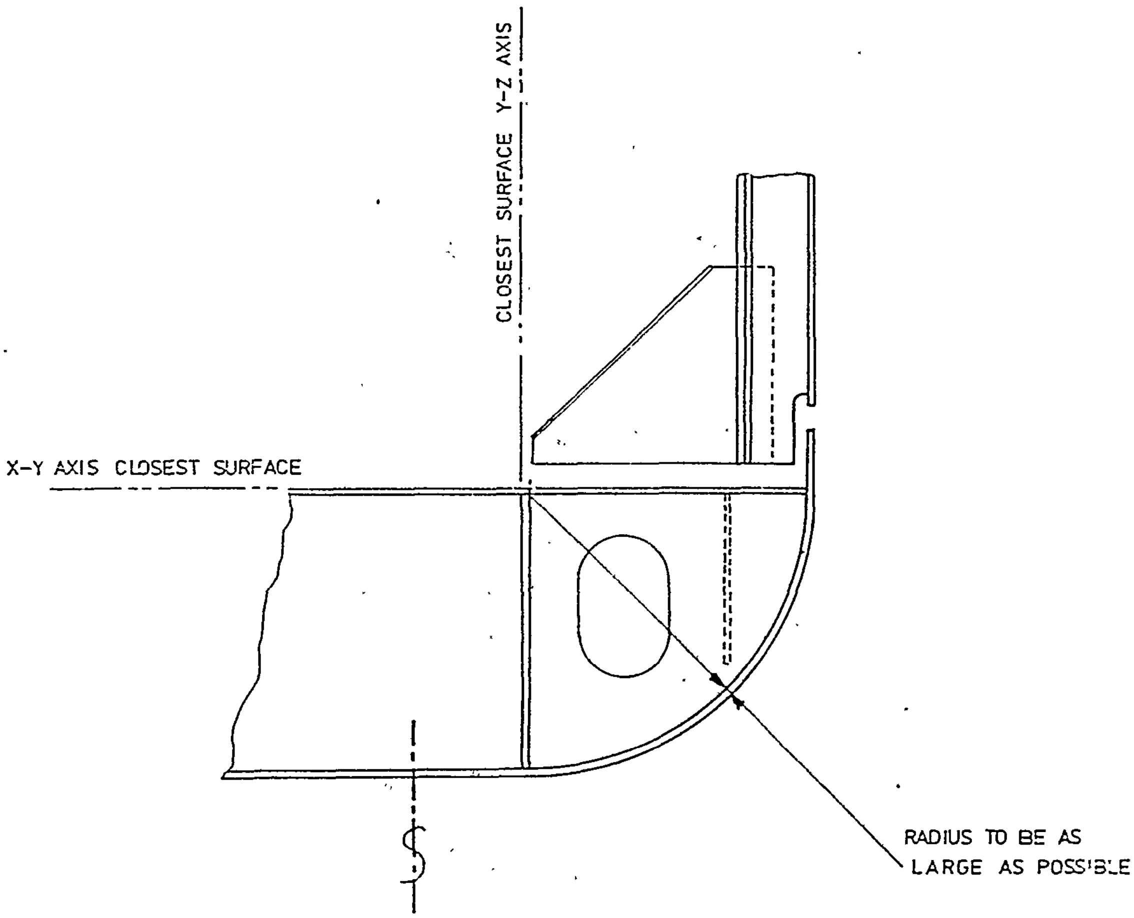
Steelwork design at all levels of detail should be directed towards effective use of facilities and manpower as they exist in the industry. The ship designer should always aim to remove the inherent work content in a design (Ref. fig 7).

Unit and block divisions should be based on the natural divisions within the hull structure and should be of a standard length over as long a length of the ship as possible, as close as possible to the maximum material length or a multiple of it that may be readily handled within shipyard facilities (Ref. fig 8).

Simple geometric shapes to reduce the variety of complicated shapes should be used to improve the efficiency of pipework manufacture and installation.

Units and blocks should be defined so as to be self supporting, capable of progressive erection and easily faired and welded, with the provision of access and working platforms wherever possible by the structural features of the hull (Ref. fig 9).

For a given weldment in specified scantlings, the length of welding can be minimised by design considerations. Joints should be designed to reduce the work prior to welding.



ARRANGEMENT OF BILGE PLATING

Fig. 1

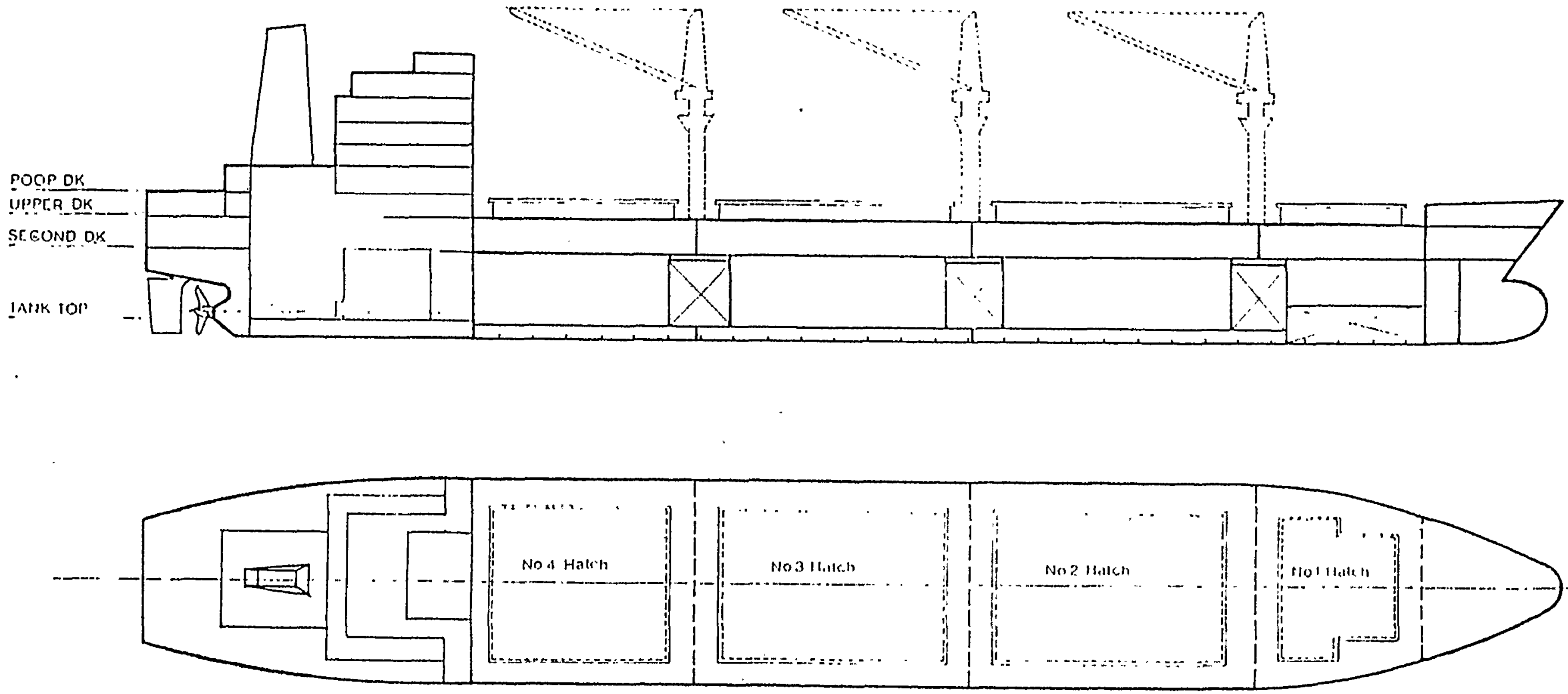
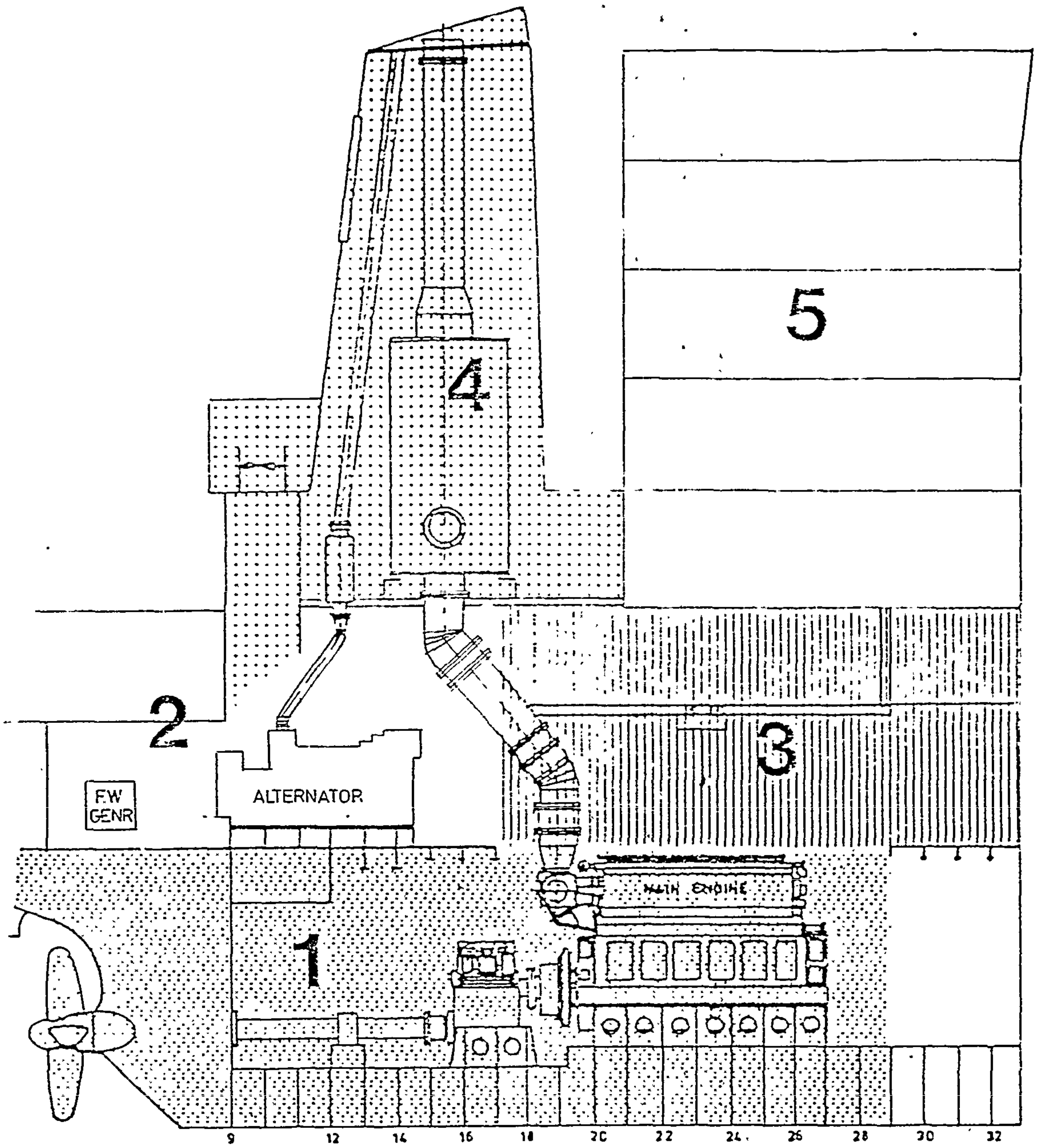


Fig 2

TYPICAL 17,800 DWT MULTI PURPOSE CARGO SHIP

Showing - **Continuity of internal surfaces**
- **Separation of functional spaces**
- **Effective use of surfaces and spaces**



KEY.
1. MAIN PROPULSION
2: AUXILIARY
3. ANCILLARY
4. EXHAUST
5. ACCOMMODATION AND SHIP CONTROL

CENTRE LINE ELEVATION
OF MACHINERY SPACE OF A 3,600 BHP VESSEL

Showing - Separation of functional spaces

Fig. 3

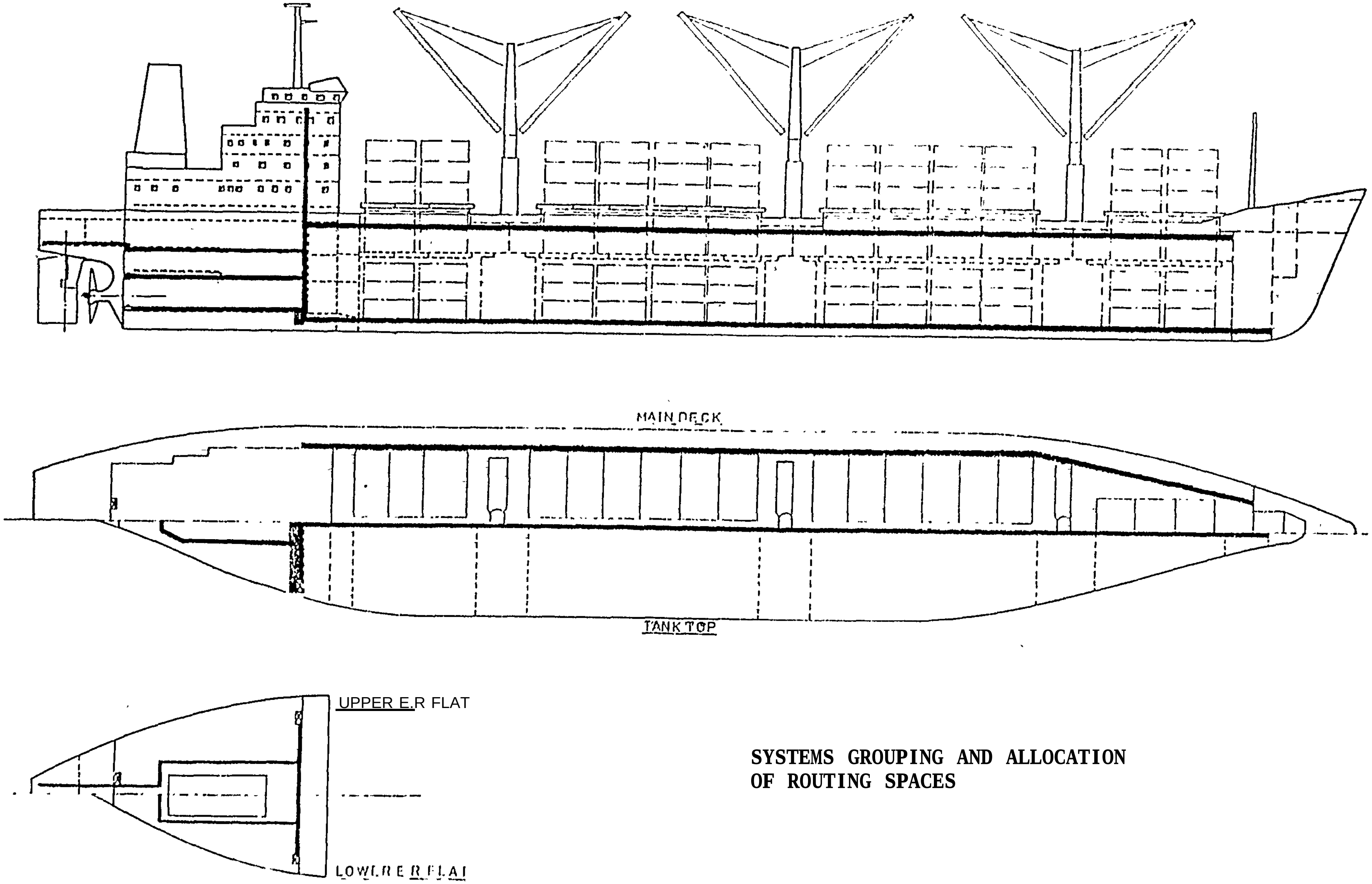
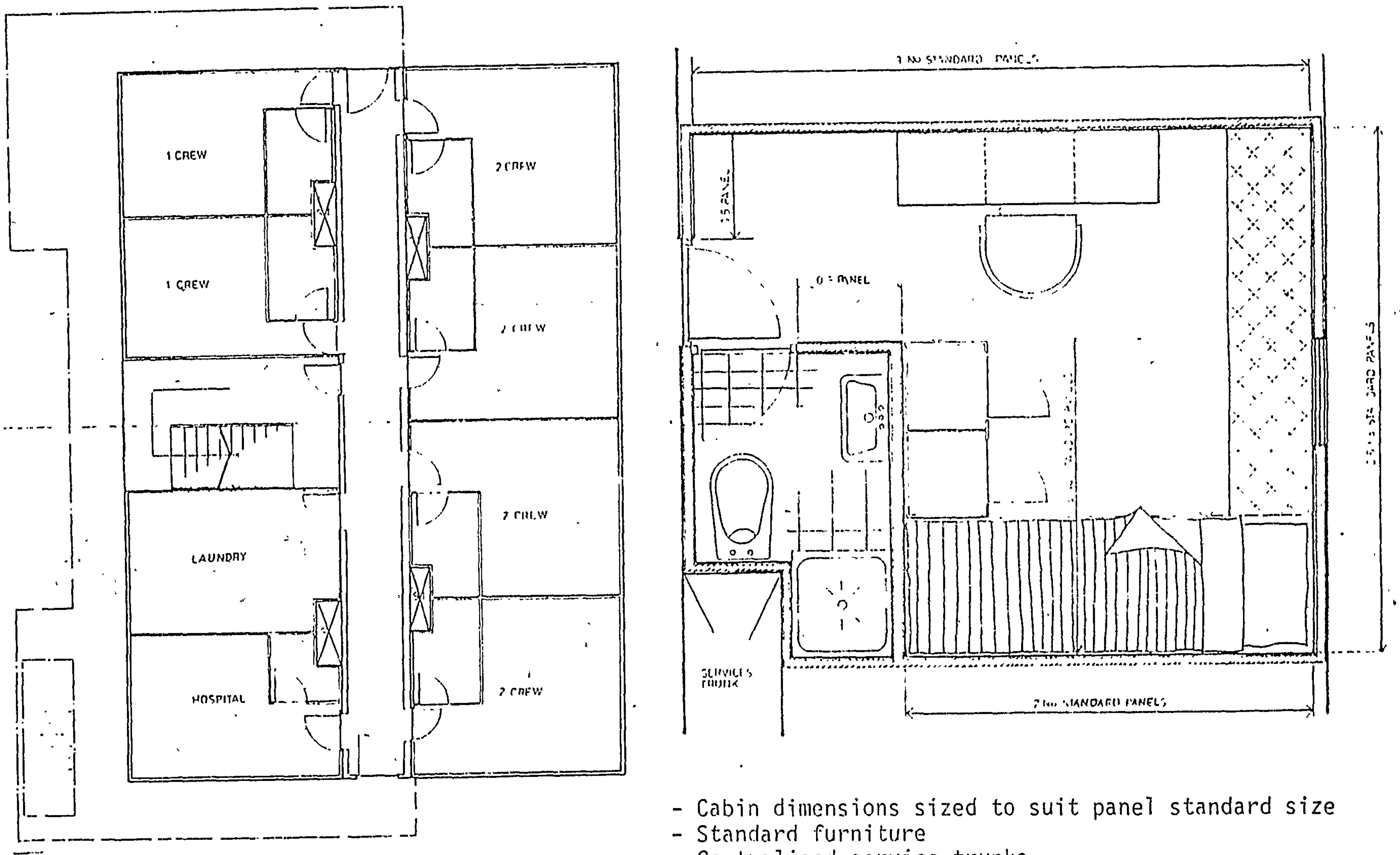


Fig. 4

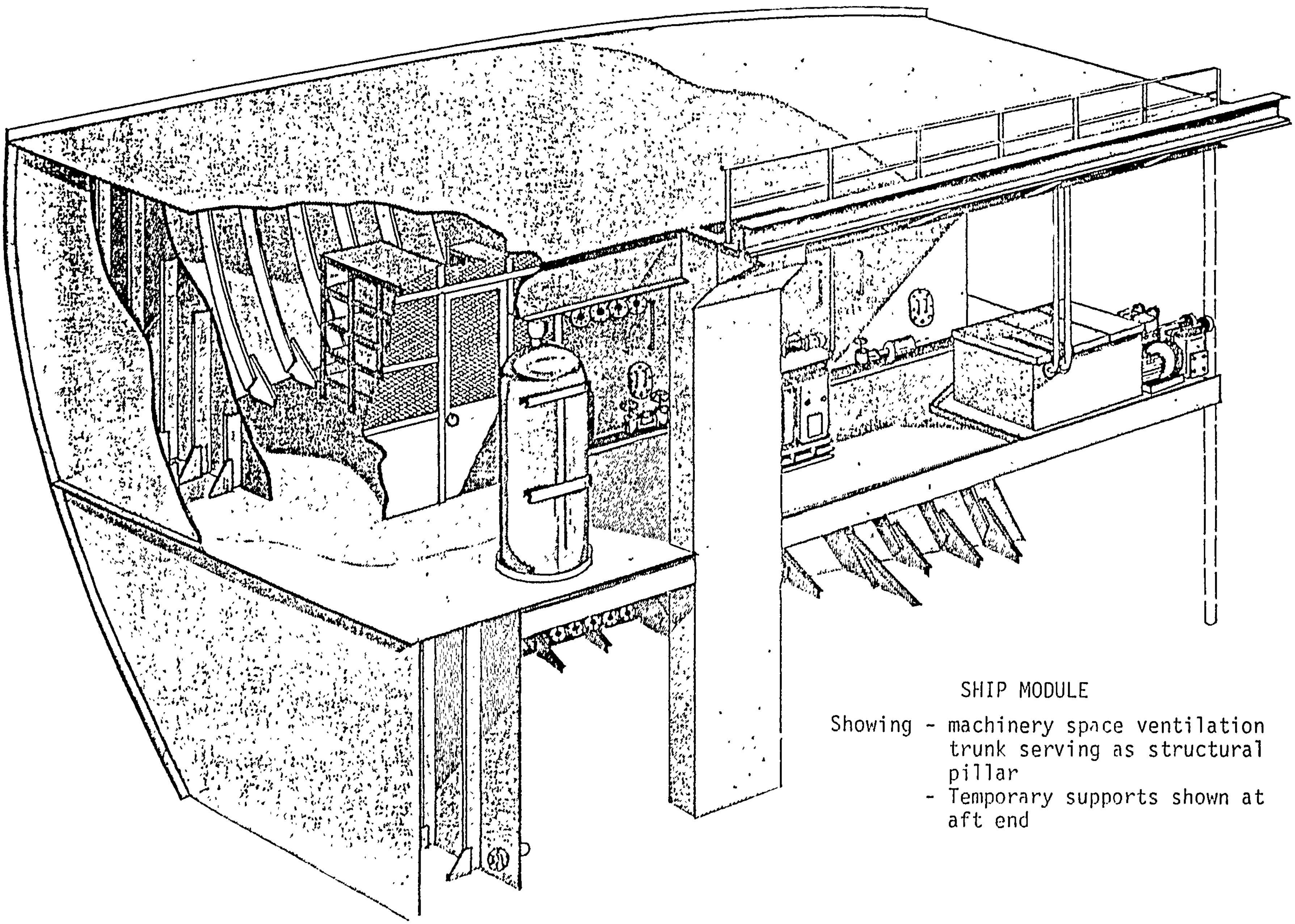
SYSTEMS GROUPING AND ALLOCATION
OF ROUTING SPACES

ACCOMMODATION LAYOUT OF 4000 DWT CONTAINER SHIP



- Cabin dimensions sized to suit panel standard size
- Standard furniture
- Centralised service trunks

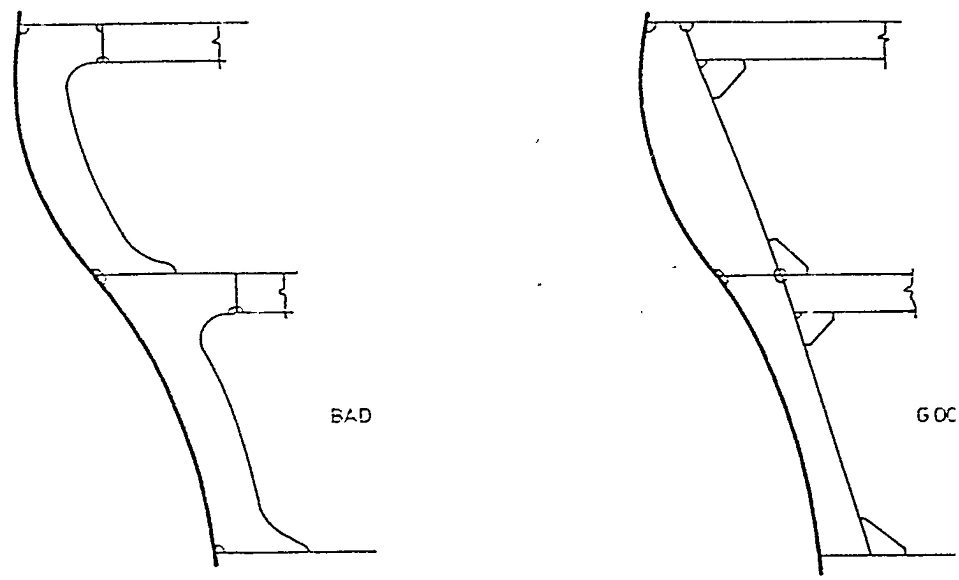
Fig. 5



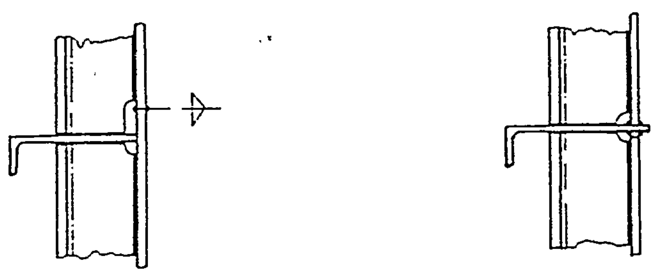
SHIP MODULE

Showing - machinery space ventilation trunk serving as structural pillar
- Temporary supports shown at aft end

Fig. 6



ELIMINATION OF ROLLED FACE FLATS



BAD

GOOD

POSITION OF SHELL PLATE JOINTS

Fig. 7

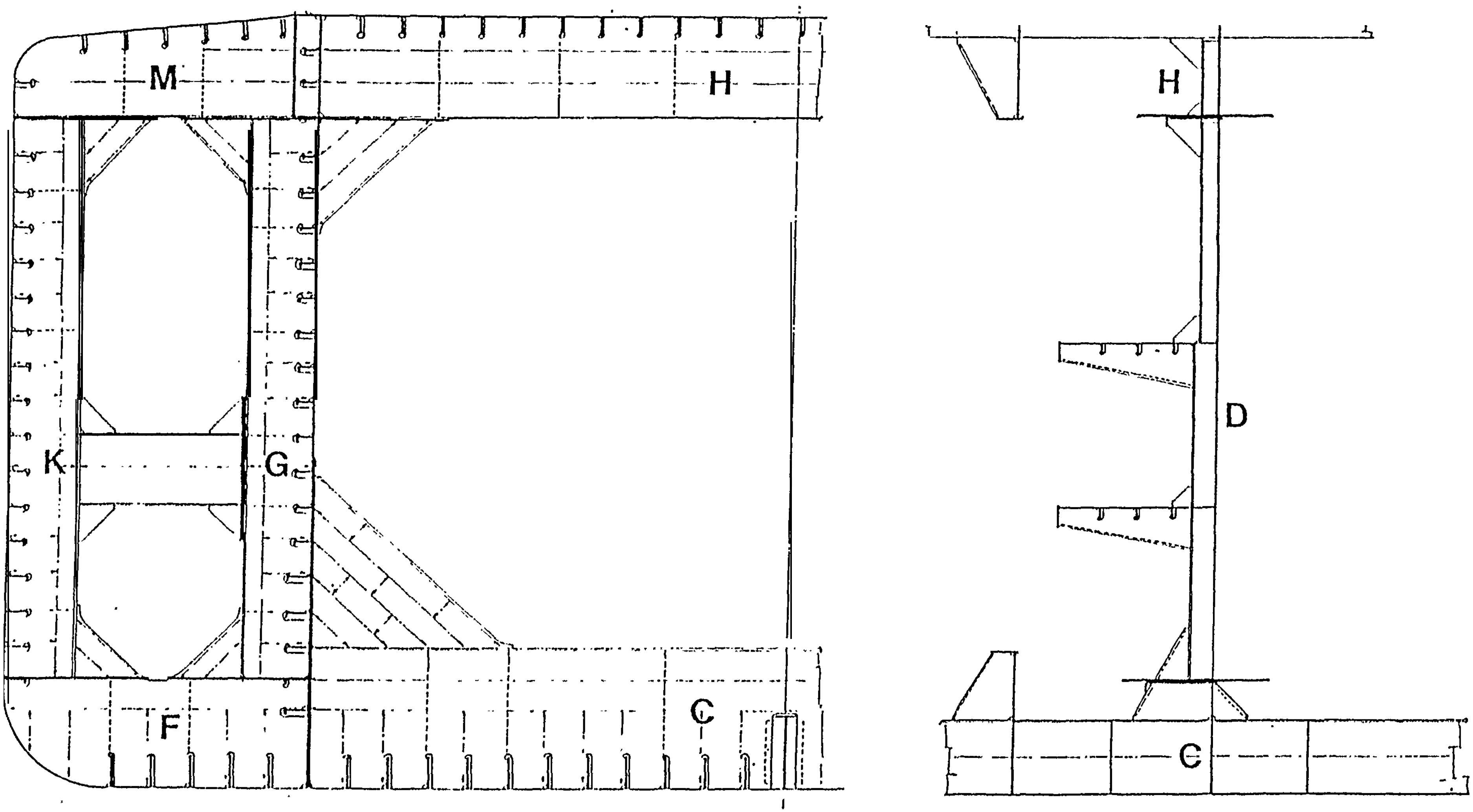
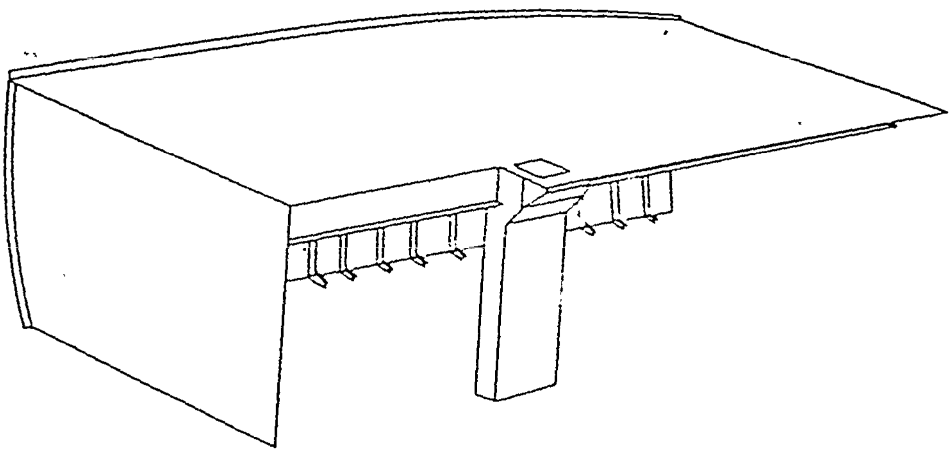
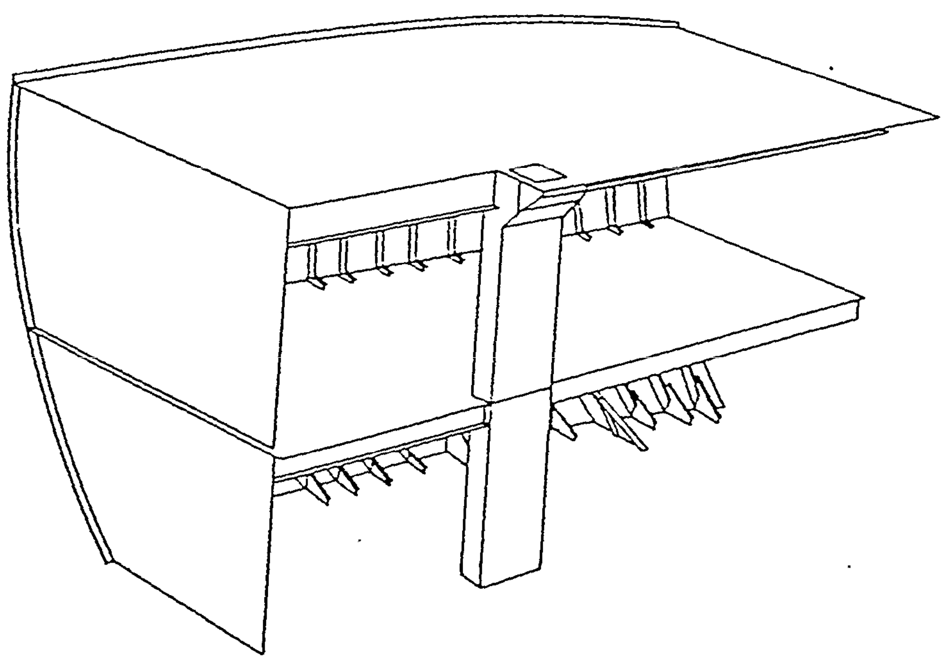


FIG.3

BLOCK BREAKDOWN OF 60,000 DWT TANKER



STEELWORK UNIT



STEELWORK BLOCK

Fig. 9

GROUP TECHNOLOGY AND AUTOMATED PROCESS PLANNING, A CHANGE IN MANAGEMENT STRATEGY

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ABSTRACT

The trend toward increased customization is increasing the problems associated with batch manufacturing, both in design and manufacturing itself. Group technology helps to solve these problems and is thus attracting great interest. The benefits of group technology in such applications as design retrieval, design standardization, standardization of machine tool routings, automated process planning, and machine tool investment can bring about dramatic savings in the multi-billion dollar manufacturing industry.

INTRODUCTION

Three or four years ago, only a handful of companies were interested in group technology. Today, many companies, including a number considered to be highly conservative, are seriously considering or have adopted group technology systems.

This increased interest is a reflection of a growing awareness of the potential benefits of group technology, particularly for batch manufacturing.

These advantages can apply to both design and manufacturing.

What is Group Technology?

Group Technology is an approach to finding common solutions for the same or similar problems. It is a means of helping designers to find the best possible design solutions quickly, and of helping manufacturing engineers to solve industrial engineering problems optimally. It provides consistent solutions to current problems, based on experience. It does this in part through an identification method which classifies and codes design and manufacturing characteristics of parts and by then making design and manufacturing solutions based on these attributes available for future use.

Trends Toward Customization

In recent years there has been a growing demand for more customized products. There are several reasons for this:

- sharper competition and new approaches to marketing have led to multiplicity of special features and options, often on products which once had little variation;

- increasing energy costs have spurred interest in alternative ways of doing things, and thus in more customized product requirements.

- new materials have encouraged exploration of new product variations:

- OSHA regulations have made many changes and variations necessary;

- increased durability demands have been "brought on by skyrocketing maintenance costs and have resulted in more stringent product requirements.

Design Implications

All of these influences have led to more and more special designs, which, of course, mean many nonstandard parts. As the number of different parts increases, batch sizes grow smaller. With smaller batch sizes, design costs per unit become higher.

Parallel with all of this is the traditional lack of communication between design and manufacturing operations. There is little feedback to the designer about the impact of design decisions on manufacturing costs. A minor design change can add a great deal to manufacturing costs; when designers do not understand the ramifications of their decisions, costs are bound to increase.

Day-to-Day Design Problems

The increasing demand for customized products has a daily impact on designers.

When a request for a new part comes into the design department, the designer is faced with several immediate questions. Among them are:

- Is it a new part?

- Have we made it before?

- Have we made a similar part before?

Conventional design retrieval systems are often inadequate to provide the needed answers. A search. of the files may require hours and still lead to nothing. More sophisticated

questions, such as those relating to potential manufacturing costs, are even more difficult to answer.

Rather than struggle with-the inadequate information system, designers will most often save time and frustration by simply creating a new design.

In a significant portion of the cases, a design for the part, or something quite similar, will already be in the files. Thus, the designer *is* "reinventing the wheel". The new design may be slightly different, however - - he may arbitrarily specify a different tolerance, for example.

Unnecessary design proliferation is the result.

Design files grow, and designs become even more difficult to retrieve. There may be 50,000 drawings in the files, and only 5,000 active parts for manufacture.

Group Technology and Design

An effective group technology system can solve these day-to-day problems through its coding and classification applications. Design retrieval is made very simple. Design analysis and standardization become feasible, and new channels of communication can be opened between design and manufacturing,

Coding and classification, especially with a computerized system such as MICLASS, is simple.

The designer begins with a rough sketch of the part. Through a computer terminal, which is hardly more complex than a typewriter, he is asked to describe the characteristics of the part by answering a series of questions. The computer asks specific questions, and the designer responds by typing in "yes" or "no" answers, or dimensions. No special computer training should be required.

To be effective, the group technology system must have a rapid retrieval capability. With such a capability, the designer can immediately find out if the part has never been designed before, whether it has been designed in the past, or if there is a drawing of a similar part already in the files.

The system should also have the computer software required to extract other relevant information from datafiles. cost information, for example, should be available to the designer as well as to manufacturing personnel.

Impact of Group Technology

When we look at the total costs of batch manufacturing operations, it appears that design accounts for only a small portion of these costs - - usually around 15%. The remaining 85% is attributable to manufacturing. Thus, while a comprehensive group technology system can have a very useful impact in design, the potential for major benefits lie in manufacturing. Companies which commit themselves to group technology for design applications only are not really taking advantages of the significant benefits of group technology.

Group Technology Benefits for Manufacturing

A comprehensive computerized group technology system can benefit manufacturing operations in a number of ways:

Retrieval of manufacturing information: A computerized group technology system, such as the MICLASS system, classifies and codes design and manufacturing information. With such information, which includes data on the company's manufacturing capabilities, it is possible to efficiently retrieve and analyze manufacturing information. It is possible to standardize manufacturing process planning and implement automated process planning.

Retrieval of manufacturing costs: Group technology also makes it possible to retrieve manufacturing costs, based on previous experience, and thus reduces the risk in making quotations. In addition, it helps make the designer aware of the manufacturing costs which result from his design decisions.

Grouping of parts: The same or similar parts can be grouped together according to their manufacturing characteristics. The formation of families of parts greatly reduces the number of "unique"' situations with which manufacturing must deal. Instead of 1,000 different parts, for example, there may be 10 groups of 100 similar parts each.

Dedication of machine tools: Not only is it possible to group parts together by their manufacturing characteristics, it is also possible to dedicate groups of machine tools to produce these families of parts; by taking into account lot sizes, releases per year, and machine tool capacities. This does not require-the physical moving of machine tools into groupings, but rather dedicating them to the parts involved.

This grouping of parts into families and dedicating groups of machine tools to produce them, leads to what we might

call a "Door man's way" of mass production-; With the number of variables in a batch manufacturing operation significantly reduced, a number of efficiencies become practical. These. include:

- Reduction in set-up time - - with similar parts coming through each machine all the time, very few,, if any, drastic changes have to be made in, set-ups.

- Reduction' in process planning time - - with the standardization of manufacturing process plans for these, families of parts, and especially with automated process planning, production planning time is significantly reduced. Past experience is utilized to the maximum:

- Reduction in durable tooling - - because machine tools are better utilized by switching to more dedicated tools for families of parts, capacity can be maximized without unnecessary machine tool investments.

- Less scrap - - since families of similar parts flow more or less continuously across groups of dedicated machine tools, machinists are not faced with "new" parts all the time. This leads to more consistent proficiency in production: With increased proficiency, there is less scrap (and lower quality control costs).

- More efficient machine tool use - - the dedication of machine tools to families of parts, and design and manufacturing standardization, mean that machine tools are used much more efficiently than with conventional approaches to batch manufacturing.

- Easier machine tool loading and scheduling with fewer variables- and the power of the computer, scheduling and loading become much less complex and much more efficient.

- Reduction in throughput time - - all of this obviously leads to shorter throughput time, by switching to semi-mass production techniques.

- Lower work in process - -_ as throughput, time decreases, and parts move more quickly and efficiently through the production cycle, the amount of work in process drops accordingly.

Impact on Small Batch Manufacturing

Increased customization has had an even greater impact on manufacturing than on design operations. As product variations increase, lot sizes decrease in size. This has an immediate effect on manufacturing costs and operations.

In addition to more product variations, manufacturing management must also contend with the increasing difficulty in finding competent production personnel, and the growing shortage of capital available for production equipment.

The conventional response to the need for more product variations is to emphasize shop flexibility.

This in turn leads to requirements for more machine tools, which results in high machine tool investment costs per unit produced.

Set-up times and costs increase, reflecting smaller lot sizes and requirements to reset for each lot. Machine tool use grows increasingly inefficient.

Related to this, scheduling and machine loading become more complex as the number and variety of lots grow. In addition, personnel seem to be constantly learning how to make new parts. Scrap rates are high, quality control costs are also high, and personnel are inefficiently used. When we recognize the problems of finding competent personnel, these problems become even more intense.

With small lot sizes, process planning costs per unit increase. The process planner is faced with problems which parallel those of the designer. When a design for a new part is received, the process planner usually has no efficient means of determining whether or not a process plan for the part, or a similar part, already exists. There may be immense files of process plans, but without an efficient and effective retrieval mechanism, past experience is useless to the process planner. As a number of designs proliferate, so do the number of process plans. Process planning costs grow along with all the other costs.

On the shop floor, material handling costs grow steadily, especially with functional shop layouts.

The overall results of all of this are long throughput times, high work in process inventories, and inefficient machine tool use.

All of the above are interrelated in many ways. The basic principle is that, through group technology, mass production efficiencies and economies are well within the realm of possibility.

Machine tool purchases: The analysis applications inherent in group technology systems make it possible to determine machine too1 needs much more accurately than with conventional methods. As a result, decisions on machine tool purchases can be made with an understanding of their potential ramifications in the production process.

The Multi-billion Dollars Revolution

In our title, we have referred to group technology as the multi-billion dollar revolution. Batch manufacturing involves many billions of dollars each year, and group technology can bring about very significant savings in both design and manufacturing.

The wide scale application of group technology is so new that extensive documented figures relating to savings are just now becoming available. There is enough data, however, to provide good indications of the savings that can be expected.

Design Savings

Design retrieval and design standardization cuts design costs by 5 to 10%. These percentages can run somewhat higher - - to 15% - - depending on how organized the company was before implementing group technology.

Manufacturing Savings

The biggest savings from group technology are in manufacturing, rather than in design. This is quite appropriate since, as we pointed out before, the overwhelming portions of total costs are in manufacturing, rather than in design.

Our experience has indicated:

- Savings in set-up time of 40 to 60%.
- A 10 to 30% increase in manufacturing capability, without additional machine tool purchases..
- A 40 to 60% reduction in throughput time and parallel savings in work in process and finished parts storage.

There are still other savings. The standardization of manufacturing processes and the communication, through computerized parts characterization, between manufacturing and design

means that designers can design with manufacturing capabilities in mind.

One can also anticipate a reduction in manufacturing time through the better use of Numerically Controlled machine tools. NC tapes can be generated for families, reducing the number of NC tapes required for individual parts. As a result, it is possible with group technology to use NC machine tools for much smaller lot sizes. We know of one case where the economical lot size was reduced from 25 to 1 or 2.

The use of NC tools for smaller lot sizes reduces production time, lowers scrap rates, and lowers production costs.

In closing, we should point out that group technology systems are not free. There are not only the costs of buying the system, which are relatively small; there are - - also the costs associated with implementing it. A great deal of work is required and the people involved in the implementation must be good at their jobs.

Most of all, there must be a strong management commitment and top management involved in the implementation process. Group technology can bring design and manufacturing personnel together in may new ways. Local interdepartmental differences must be resolved in the process, and this can only be done with top management involvement.

The benefits are well worth the costs, however, as we have attempted to point out. Group technology is a revolution which is only now in its infancy. In the years to come, we expect to see the wide spread use of group technology in the United States and throughout the world. It will be a multi-billion dollar revolution.

INTEGRATING SHIPYARD DESIGN AND MANUFACTURING FUNCTIONS INTO AN EXISTING CAD/CAM SYSTEM

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Prior to his involvement with Manufacturing and Consulting Services Inc, Dr. Hanratty held the positions of President at Integrated Computer Systems, Manager of Automation Methods at Douglas Astronautics, Manager of Process Control at General Electric Computer Department, and Designer at General Motor Research Labs.

AD-2000 FUNCTIONS

1 MODALS AND FONTS
2 BLANK/UNBLANK
3 DELETE
4 FILE/TERMINATE
5 SPECIAL FUNCTIONS/APPLICATIONS
6 DATA BASE MANAGEMENT
7 INPUT/OUTPUT/REGENERATION
8 DISPLAY/DEPTH CONTROL
9 POINT
10 LINE
11 ARC/CIRCLE/FILLET
12 OTHER CURVES
13 ENTITY MANIPULATION
14 DATA VERIFY
15 EXTENDED GEOMETRY
16 DRAFTING
17 N/C MACHINING
18 ANALYSIS,
19 SIU/ENGLISH/RESIZE

FUNCTION CONTROL KEYS

[= REJECT
] = OPERATION COMPLETE
C = READ CROSSHAIR CURSOR
Y YES
N NO
M CHANGE MENU DISPLAY
R REPAINT THE DISPLAY
Z WINDOW (ZOOM)
D CHANGE DEPTH
F AD-2000 FUNCTIONS
CP POINT
CL LINE
CA ARC/CIRCLE
CD DELETE LAST ENTITY
P MOMENTARY POINT SELECT
L MOMENTARY LINE SELECT
A MOMENTARY ARC SELECT
O MOMENTARY OTHER CURVES SELECT
S MOMENTARY SPLINE SELECT
T MOMENTARY TEXT SELECT
? "HELP" FUNCTION
! DATA CAPTURE

1 MODALS AND FONTS

1 MENU DISPLAY
2 CONSTRUCTION MODAL
3 DISPLAY TOLERANCE
4 SYSTEM DECIMAL PLACES
5 CURVE FONT
6 MODIFY ENTITY FONT
7 MODIFY ENTITY LEVEL/PEN NO.
8 SURFACE PATHS
9 CURSOR MODE
10 VIEW VECTORS
11 SEQ.NO./POINTER SELECT
12 DISPLAY MODAL STATUS
13 DISPLAY TITLE BLOCK

1-5 CURVE FONT

1 SOLID
2 DASHED
3 PHANTOM
4 CENTERLINE

1-6 MODIFY ENTITY FONT

1 SOLID
2 DASHED
3 PHANTOM
4 CENTERLINE

2 BLANK/UNBLANK

1 BLANK ALL OF A SPECIFIC TYPE
2 BLANK ALL EXCEPT A SPECIFIC TYPE
3 BLANK ALL
4 BLANK, SELECT FROM SPECIFIC TYPE
5 BLANK, SELECT FROM ALL
6 BLANK ALL EXCEPT N1 TO N2
7 BLANK LEVELS
8 UNBLANK ALL
9 UNBLANK ALL OF A SPECIFIC TYPE
10 UNBLANK ALL EXCEPT A SPECIFIC TYPE
11 UNBLANK N1 TO N2
12 UNBLANK LEVELS

2 & 3 ENTITY TYPES

1 POINTS
2 LINES AND POINT SETS
3 ARCS AND CIRCLES
4 OTHER CURVES
5 ARRAYS AND GROUPS
6 EXTENDED GEOMETRY
7 LABELS, DIMENSIONS AND NOTES
8 CENTERLINES
9 CROSS-HATCHING
10 POINT-TO-POINT PATHS
11 N/C PATHS (NON POINT-TO-POINT)

5 SPECIAL FUNCTIONS

1 CANON
2 GRAPL-II
3 MANAGE VARIABLES
4 USER DEFINED SYMBOLS
5 LEVEL MANAGEMENT
6 ATTRIBUTE MANAGEMENT
7 DATA GRAPHS*
8 APPLICATIONS

5-2 GRAPL-II

1 VARIABLE CALCULATION
2 INPUT/EDIT GRAPL-II PROGRAMS*
3 AUTO GRAPL-II**
4 RUN GRAPL-II PROGRAM**

5-3 MANAGE VARIABLES

1 MOVE VARIABLES FROM UTF TO RTL
2 MOVE VARIABLES FROM RTL TO UTF
3 LIST TECHNOLOGY FILE VARIABLES
4 LIST RUN TIME LIBRARY VARIABLES

5-5 LEVEL MANAGEMENT

1 CHANGE LEVEL/PEN NO.
2 DEFINE LEVELS
3 LIST LEVELS
4 DELETE LEVELS
5 INITIALIZE LEVELS

5-6 ATTRIBUTE MANAGEMENT

1 CREATE
2 INTERROGATE
3 DELETE**

5-6-2 INTERROGATE

1 RETRIEVE
2 IDENTIFY MINIMUM
3 IDENTIFY MAXIMUM
4 FIND TOTAL
5 CONSTRAINED RETRIEVE
6 DISPLAY

5-6-2-5 CONSTRAINT RELATIONALS

1 LESS THAN
2 LESS THAN OR EQUAL
3 EQUAL
4 NOT EQUAL
5 GREATER THAN OR EQUAL
6 GREATER THAN

5-7-1 DATA GRAPHS*

5-7-1 DATA GRAPH TEMPLATE MODES

1 RETRIEVE
2 SELECT FROM SCREEN
3 CREATE

5-7-1 GRAPH TYPE

1 LINEAR
2 POLAR
3 PIE

5-7-1 PLOT TYPES

1 POINT PLOT
2 LINE PLOT
3 FUNCTION
4 HISTOGRAM
5 HORIZONTAL BAR GRAPH
6 VERTICAL BAR GRAPH

6 DATA BASE MANAGEMENT

1 PART MANAGEMENT
2 PATTERN MANAGEMENT
3 TEMPLATE MANAGEMENT**
4 FIGURE MANAGEMENT**
5 USER TECHNOLOGY FILE MANAGEMENT
6 DATA BASE INFORMATION
7 DUMP CURRENT PART

6-1 PART MANAGEMENT

1 SAVE PARTS ON TAPE
2 RESTORE PARTS FROM TAPE
3 LIST ON-LINE PART FILE
4 COPY PART UNDER NEW NAME
5 DELETE A PART
6 CHANGE PART STATUS
7 MERGE INTO CURRENT PART**

6-2 PATTERN MANAGEMENT

1 CREATE A PATTERN
2 RETRIEVE A PA-i-TERN
3 DELETE A PATTERN
4 LIST ON-LINE PATTERN FILE
5 INITIALIZE PATTERN LIBRARY
6 SAVE PATTERNS ON TAPE**
7 RESTORE PATTERNS FROM TAPE**

6-3 TEMPLATE MANAGEMENT**

1 CREATE A TEMPLATE
2 RETRIEVE A TEMPLATE
3 DELETE A TEMPLATE
4 LIST ON-LINE TEMPLATE FILE
5 INITIALIZE TEMPLATE LIBRARY

* NOT AVAILABLE ON 16 BIT COMPUTERS
** AVAILABLE DECEMBER, 1979

6-4 FIGURE MANAGEMENT**

1 CREATE A FIGURE
2 RETRIEVE A FIGURE
3 DELETE A FIGURE
4 LIST ON-LINE FIGURE FILE
5 INITIALIZE FIGURE LIBRARY

6-5 USER TECHNOLOGY FILE MANAGEMENT

1 LIST
2 DELETE
3 SAVE ON TAPE
4 RESTORE FROM TAPE
5 INITIALIZE

6-6 DATA BASE INFORMATION

1 ENTITY INFORMATION
2 CURRENT PART SPACE
3 PART LIBRARY SPACE
4 PATTERN LIBRARY SPACE
5 USER TECHNOLOGY FILE SPACE

6-7 CURRENT PART DUMP

1 INSPECT COMMON VALUES
2 DUMP ENTITIES BY SEQ.NO.
3 DUMP ENTITIES BY LEVEL

7 INPUT/OUTPUT/REGENERATION

1 OUTPUT CL-FILE/CLPRINT
2 PLOT
3 DISPLAY LAST SEQ. NO. USED
4 DISPLAY ENTITY SEQUENCE NUMBER
5 IDENTIFY ENTITY NUMBER N
6 IDENTIFY ENTITIES Nl TO N2
7 REGENERATE ENTITY NUMBER N
8 REGENERATE FROM Nl TO-N2
9 REGENERATE ALL
10 BULK DATA INPUT
11 USER I/O INTERFACE

8 DISPLAY/DEPTH CONTROL

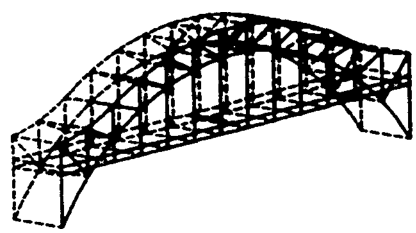
1 ZOOM
2 CHANGE DEPTH
3 CHANGE VIEW(S)
4 CHANGE WORK-VIEW
5 DEFINE AUXILIARY VIEW
6 Z-CLIP

8-1 ZOOM CONTROL

1 RETURN TO ORIGINAL SCALE
2 SELECT A NEW CENTER
3 SELECT NEW CENTER & DOUBLE SCALE
4 SELECT NEW CENTER & HALF SCALE
5 SELECT NEW CENTER & KEY-IN SCALE
6 DOUBLE SCALE
7 HALF SCALE
8 KEY-IN SCALE
9 DIAGONAL POINTS
10 KEY-IN MAX-MINS
11 AUTO MAX-MINS
12 SAVE ZODM STATUS

8-5 AUXILIARY VIEW DEFINITION

1 NORMAL AXIS CW
2 NORMAL AXIS, CCW
3 HORIZONTAL AXIS TOP OUT
4 HORIZONTAL AXIS TOP IN
5 VERTICAL AXIS RIGHT OUT
6 VERTICAL AXIS RIGHT. IN
7 ROTATE ABOUT ANY LINE
8 PARALLEL TO A PLANE
9 KEY-IN MATRIX
10 COPY AS A NEW VIEW



** AVAILABLE DECEMBER, 1979

9 POINT

1 SCREEN POSITION
2 KEY-IN COORDINATES
3 POLAR
4 DELTA
5 VECTORED
6 CIRCLE CENTER
7 ON A CIRCLE AT AN ANGLE
8 CURVE ENDPOINT
9 INTERSECTION OF TWO CURVES
10 REGENERATE SPLINE POINTS
11 ON A LINE
12 CURVE NORMAL POINT
13 BEARING/DISTANCE
14 ON A CURVE AT A PARAMETER
15 SURFACE NORMAL/PIERCE POINT
16 SPHERICAL
17 FAN POINTS
18 INCREMENTAL POINTS
19 MODIFY/REPLACE

10 LINE

1 SCREEN POSITION
2 KEY-IN COORDINATES
3 JOIN OF TWO POINTS
4 TANGENT TO TWO CURVES
5 THRU POINT AND HORIZ. OR VERTICAL
6 THRU POINT AND TANGENT TO A CURVE
7 POLAR LINE
8 THRU POINT AND PARALLEL TO A LINE
9 THRU POINT AND PERPTO A LINE
10 PARALLEL TO A LINE AT A DISTANCE
11 PARALLEL TO A LINE, TANTO A CURVE
12 PERPTO A LINE, TANGENT TO A CURVE
13 DIVIDE LINE INTO N SEGMENTS
14 JOIN TWO CURVES
15 MODIFY STATUS (INFINITE/NON-INFINITE)
16 AXIS DEFINITION
17 CHAMFER
18 MODIFY/REPLACE

11 ARC/CIRCLE/FILLET

1 SCREEN POSITION AND RADIUS
2 KEY-IN CENTER AND RADIUS
3 CENTER POINT AND RADIUS
4 CENTER POINT AND TANGENT LINE
5 CENTER POINT AND TANGENT CIRCLE
6 CENTER POINT AND POINT ON EDGE
7 THROUGH THREE POINTS
8 MODIFY ANGLES
9 FILLET
10 INSCRIBED IN THREE LINES
11 NORMAL TO VIEW
12 MODIFY/REPLACE

12 OTHER CURVES

1 SPLINE
2 OFFSET CURVE
3 CONICS
4 STRING
5 MAKE STRING FROM LINES/ARCS
6 MAKE LINES/ARCS FROM STRING
7 N-GON
8 TRIM CURVES
9 CONVERT STRING TO POINT SET CURVE

12-3 CONICS

1 ELLIPSE
2 HYPERBOLA
3 PARABOLA
4 GENERAL CONIC
5 LOFT CONIC
6 RHO CONIC
7 CYLINDER SLICE

12-4 STRING

1 SCREEN POSITION
2 KEY-IN COORDINATES
3 EXISTING POINTS
4 DELTA
5 POLAR
6 BEARING
7 CW ARC
8 CCW ARC
9 CONNECT TO CURVE
10 INDICATE ARC
11 CLOSE OPTIONS

12-7 N-GON

1 TRIANGLE
2 RECTANGLE
3 HEXAGON

12-8 TRIM MODE

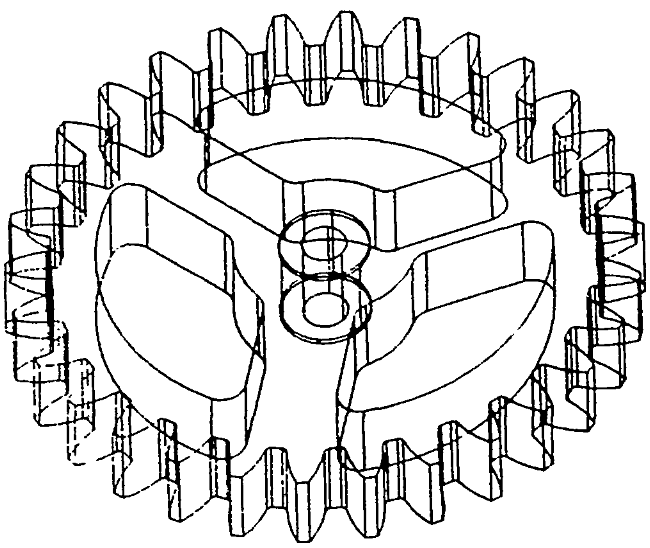
1 ONE END
2 BOTH ENDS
3 MIDDLE
4 TWO CURVES AT INTERSECTION

13 ENTITY MANIPULATION

1 RECTANGULAR ARRAY
2 CIRCULAR ARRAY
3 GROUP
4 MIRROR
5 TRANSLATE
6 ROTATE
7 DUPLICATE AND TRANSLATE
8 DUPLICATE AND ROTATE
9 ARRAY EXPLODE
10 STRETCH

14 DATA VERIFY

1 POINTS
2 LINES
3 ARCS AND CIRCLES
4 SPLINES
5 ELLIPSES
6 HYPERBOLAS
7 PARABOLAS
8 ARRAYS
9 GROUPS
10 GENERAL MEASUREMENTS
11 DRAFTING ENTITIES
12 TRIANGLES, RECTANGLES, HEXAGONS



15 EXTENDED GEOMETRY

1 3-D CURVES
2 SURFACES
3 SOLIDS
4 CROSS SECTION SLICE
5 DEVELOPABLE SURFACE LAYOUT

15-1 3-D CURVES

1 3-D SPLINE
2 SURFACE EDGE CURVE
3 SURFACE INTERSECTION CURVE
4 DRAFT OR MACHINE CURVE
5 COMPOSITE CURVE
6 VECTOR

15-2 SURFACES

1 PLANE
2 SURFACE OF REVOLUTION
3 3-D TABULATED CYLINDER
4 RULED SURFACE
5 DEVELOPABLE SURFACE
6 CURVE MESH SURFACE
7 FILLET SURFACE*
8 OFFSET SURFACE
9 SPHERE
10 CYLINDER
11 TORUS
12 CONE
13 COMPOSITE SURFACE
14 CHANGE PARAMS FOR NEW SURFACE
15 PROJECTED SURFACES
16 CURVE DRIVEN SURFACE

15-1-6 VECTOR

1 SCREEN POSITION
2 KEY-IN
3 TWO POINTS
4 PLANE UNIT NORMAL
5 SCALAR TIMES VECTOR
6 CROSS TWO VECTORS
7 NORMALIZED VECTOR
8 THRU PT AT GIVEN LENGTH & ANG
9 INTERSECTION OF TWO PLANES
10 SUM OR DIFFERENCE OF TWO VECTORS
11 THRU A PT AT ANG WITH LINE/VECTOR

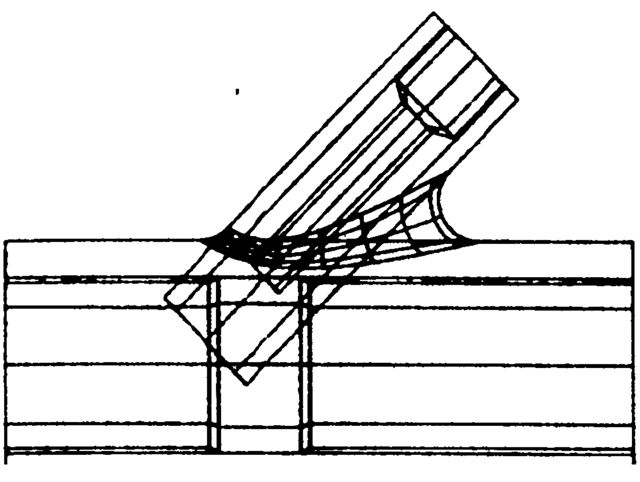
* NOT AVAILABLE ON 16 BIT COMPUTERS

15-2-1 PLANE

1 COEFFICIENTS
2 THRU THREE NON-COLLINEAR POINTS
3 THRU PT AND PARALLEL TO A PLANE
4 PARALLEL TO A PLANE AT A DISTANCE
5 THRU A PT AND PERPTO A VECTOR
6 THRU TWO PTS AND PERPTO A PLANE
7 THRU A PT AND PERPTO TWO PLANES
8 TWO LINES

15-3 SOLIDS

1 HEXAHEDRON
2 SPHEROID
3 CIRCULAR ROD
4 TOROID
5 ELLIPSOID
6 PROJECTED**
7 ROTATED**
8 FROM ORTHOGONAL VIEWS***
9 SIMULTANEOUS MULTI-VIEW CONSTRUCTION***
10 COMPOSITE***



*** AVAILABLE 1ST QUARTER, 1980

16 DRAFTING FUNCTIONS

1 DRAFTING MODALS
2 PROJECTED ENTITY
3 CROSS-HATCHING
4 HORIZONTAL DIMENSION
5 VERTICAL DIMENSION
6 PARALLEL DIMENSION
7 ANGULAR DIMENSION
8 CIRCULAR DIMENSION
9 DIAMETER DIMENSION
10 GENERAL NOTE
11 GENERAL LABEL
12 CENTERLINE
13 MODIFY DRAFTING ENTITY
14 DETAIL MAGNIFICATION
15 BALLOON
16 TRUE POSITION SYMBOLS
17 ARROWHEAD AT END OF LINE
18 THICKNESS DIMENSION

16-1 DRAFTING MODALS

1 CHARACTER SIZE
2 WITNESS LINE CONTROL
3 TEXT-ARROW CONTROL
4 AUTOMATIC DIMENSIONS
5 KEY-IN DIMENSIONS
6 CROSS-HATCHING MATERIAL
7 DECIMAL PLACES
8 FRACTIONS
9 LABEL AND DIMENSION ORIGIN
10 ARROWHEAD ALIGNMENT
11 DRAFTING SCALE FACTOR
12 CHARACTER SET CONTROL
13 SLANT STATUS (ON/OF)
14 CHARACTER DISPLAY RATIOS
15 ARROWHEAD LENGTH
16 DIMENSION OFFSET DISTANCES
17 TEXT ANGLE CONTROL
18 DUAL DIMENSIONING
19 DISPLAY DRAFTING MODALS

16-1-2 WITNESS LINE CONTROL

1 NO SUPPRESSION
2 SUPPRESS FIRST
3 SUPPRESS SECOND
4 SUPPRESS BOTH
5 LABEL LEADER TO FIRST TEXT LINE
6 LABEL LEADER TO MIDDLE TEXT LINE

16-1-3 TEXT/ARROW CONTROL

1 TEXT IN, ARROWS IN
2 TEXT IN, ARROWS OUT
3 TEXT OUT, ARROWS OUT
4 TEXT OUT, ARROWS IN

16-13 MODIFICATION TYPE

1 NEW ORIGIN
2 BASIC
3 REFERENCE
4 ADD TOLERANCE OR LIMITS
5 NEW CHAR. SIZE
6 MODIFY TEXT
7 MODIFY SLANT STATUS
8 MODIFY ANGLE
9 CHANGE TOLERANCE

16-13-6 MODIFY TEXT

1 DELETE LINE
2 INSERT LINE
3 REPLACE STRING

16-16 TRUE POSITION SYMBOL ORIGIN

1 SCREEN POSITION
2 KEY-IN
3 EXISTING POINT
4 BELOW FEATURE CONTROL BOX
5 ABOVE FEATURE CONTROL BOX

16-16 GEOMETRIC CHARACTERISTIC

1 STRAIGHTNESS
2 FLATNESS
3 ROUNDNESS (CIRCULARITY)
4 CYLINDRICITY
5 PROFILE TO A LINE
6 PROFILE TO A SURFACE
7 ANGULARITY
8 PERPENDICULARITY (SQUARENESS)
9 PARALLELISM
10 POSITION
11 CONCENTRICITY
12 SYMMETRY
13 CIRCULAR RUNOUT
14 TOTAL RUNOUT

16-16 OTHER T.P. SYMBOLS

1 MAXIMUM MATERIAL CONDITION
2 REGARDLESS OF FEATURE SIZE
3 DIAMETER
4 PROJECTED TOLERANCE ZONE

16-1-6 CROSS-HATCHING MATERIAL

1 IRON
2 STEEL
3 BRONZE, BRASS, COPPER
4 RUBBER; PLASTIC
5 REFRACTQRY MATERIAL
6 MARBLE, SLATE, GLASS
7 ZINC, LEAD, BABBITT
8 MAGNESIUM, ALUMINUM, ALUMINUM ALLOYS

16-1-9 LABEL AND DIMENSION ORIGIN

1 INDICATE POSITION
2 KEY-IN
3 DELTA
4 AUTOMATIC

16-1-12 CHARACTER SET CONTROL

F A S T
2 STANDARD
3 USER GENERATED

16-1-17 TEXT ANGLE CONTROL

1 NONE
2 ACCEPT ANGLE INPUT
3 ASK FOR PARALLEL LINE/ARC IN NOTE
4 TOTAL ANGLE CONTROL

16.12 CENTERLINE

1 POINTS
2 CIRCLE(S)
3 BOLT CIRCLE

17 N/C MACHINING

1 N/C MODALS
2 POINT-TO-POINT
3 PROFILE (PLANAR/3-AXIS/5-AXIS)
4 POCKET (PLANAR/3-AXIS/5-AXIS)
5 3-AXIS MILLING
6 5-AXIS END CUTTING
7 5-AXIS SWARF CUTTING
8 ABSOLUTE TOOL MOTION
9 LATHE
10 DEFINE CYCLE
11 DISPLAY AND EDIT
12 3 SURFACE PROFILE*
13 3-AXIS FLANGE*
14 COMPOSITE TOOL PATHS*
15 POST PROCESSORS****

17-1 N/C MODALS

1 SFM
2 TOOL PATH DISPLAY MODE
3 COOLANT
4 SPINDLE DIRECTION
5 FEED RATES
6 SPINDLE SPEED
7 CLEARANCE/RETRACT PLANES
8 TOLERANCES
9 DEEP HOLE PARAMETERS
10 RAPID FEED MODE
11 TOOL DISPLAY FOR DISPLAY & EDIT
12 DISPLAY N/C MODALS

17-1-15 TOOL DISPLAY FOR DISPLAY & EDIT

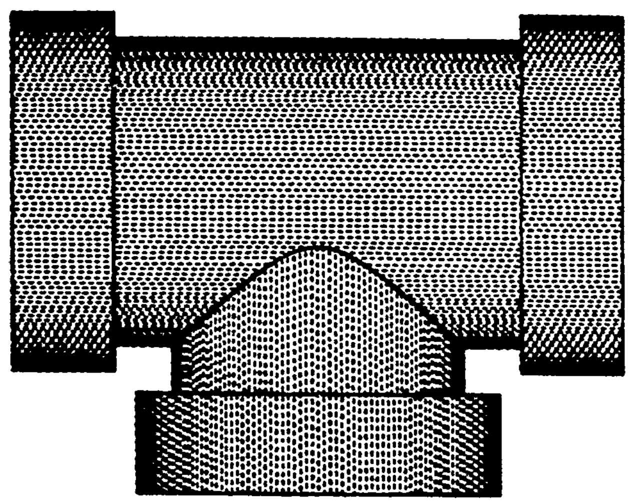
1 NONE
2 NORMAL TO VIEW
3 PARALLEL TO VIEW

17-2 POINT-TO-PQINT TOOLS

1 SPOT DRILL
2 TAP
3 DRILL
4 BORE
5 FINISH BORE
6 SPOT FACE
7 COUNTER SINK
8 REAM
9 MILL

17-10 CYCLE COMMANDS

1 CLW
2 CCLW
3 SPINDLE SPEED
4 COOLANT ON
5 COOLANT OFF
6 FLOOD COOLANT ON
7 MIST COOLANT ON
8 TAP COOLANT ON
9 PLUNGE (RAPID)
10 RETRACT (RAPID)
11 FEED TO FIXED ZT
12 FEED TO DELTA ZT FROM CURRENT DEPTH
13 FEED TO POINT + DELTA DISTANCE
14 DWELL
15 STOP
16 DEEP HOLE



* NOT AVAILABLE ON 16 BIT COMPUTERS
**** AVAILABLE AS SPECIAL ORDER ONLY

18 ANALYSIS

1 SPLINE ANALYSIS
2 ANALYTIC AREA/PERIMETER
3 2-D SECTION ANALYSIS
4 3-D ANALYSIS
5 WEIGHTS & VOLUMES
6 CURVE ANALYSIS

18-1 SPLINE ANALYSIS

1 SLOPE
2 CURVATURE
3 RADIUS OF CURVATURE
4 X vs. PARAMETER PLOT
5 Y vs. PARAMETER PLOT
6 EXTENDED ANALYSIS

18-2 2-D SECTION ANALYSIS

1 LENGTH OF PERIMETER
2 AREA
3 CENTER OF GRAVITY
4 FIRST MOMENT
5 MOMENT OF INERTIA
6 RADIUS OF GYRATION
7 POLAR MOMENT OF INERTIA
8 POLAR RADIUS OF GYRATION
9 MIN/MAX X,Y

18-4 3-D ANALYSIS

1 SURFACE AREA
2 VOLUME
3 WEIGHT
4 WEIGHT/UNIT LENGTH.
5 FIRST MOMENT OF MASS
6 CENTER OF MASS
7 MOMENT OF INERTIA
8 RADIUS OF GYRATION
9 SPHERICAL MOMENT OF INERTIA
10' SPHERICAL RADIUS OF GYRATION

18-5 WEIGHTS AND VOLUMES

1 SOLIDS
2 SURFACES TO A DEPTH

18-6 CURVE ANALYSIS

1 CURVE LENGTH
2 DERIVATIVES

CURRENT STATUS OF THE LOW COST PARTS DEFINITION PROJECT

Richard C. Moore
Manager of Steel Fabrication Engineering Development
Newport News Shipbuilding and Dry Dock Dompany
Newport News, Virginia

Mr. Moore is currently the Newport News REAPS technical representative, the Project Manager of the low cost parts definition project, and is a member of a structural CAD/CAM project. He received his degrees in naval architecture and marine engineering from the University of Michigan. Together with Doug Martin, he authored the paper, "Requirements and Benefits of Integrated Computer Aided Ship Design and Production" presented at ICCAS '79.

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INTERACTIVE GRAPHICS PART DEFINITION PROJECT

MAIN REQUIREMENTS OF IPD AS DEFINED BY NNS AND REAPS TECH REPS,

- HARDWARE/SOFTWARE PACKAGE TO ALLOW USERS- TO PERFORM REAL TIME DEFINITION OF THEIR APPLICATION WITH VISUAL (GRAPHIC) OUTPUT AND BUILD UP A DIGITAL MODEL OF THE DEFINITION AT THE SAME TIME,
- MUST BE PORTABLE AND, CAPABLE OF BEING. UPDATED AND EXPANDED INDEPENDENTLY OF THE VENDOR,
- . PROVIDE A GENERAL TOOL TO BE AVAILABLE FOR FUTURE GRAPHICS PROJECTS WITHIN U.S. SHIPBUILDING,
- DEDICATED COMPUTER HARDWARE TO PROVIDE. RESPONSE TO SUPPORT INTERACTIVE GRAPHICS.
- CAPABLE OF DIRECT INTERFACE TO AUTOKON/ SPADES/STEERBEAR SYSTEMS.

FUNCTIONAL AREAS ADDRESSED BY IPD

- STRUCTURAL PART DEFINITION (CURRENT LOFTING)
- NESTING
- STRUCTURAL SHOP DRAWINGS
- NC MACHINING (APT)
- DESIGN USE

SECONDARY EVENTS AT NNS

CONTRACT STATUS

- PHASE I - FEASIBILITY AND DESIGN STUDY
  - SYSTEM SPECIFICATION
  - HARDWARE CONFIGURATION
  - POTENTIAL VENDORS
  - BENCHMARK (WITH 8 VENDORS)
  - INTERIM REPORTS TO REAPS ADVISORY GROUP AND TECH REPS,
  - FINAL VENDOR SELECTION BY NNS WITH TECH REP APPROVAL,

COMPLETED OCT '78

- PHASE II - UPDATE MARAD PROPOSAL AND RECEIVE APPROVAL

  NNS HAS PROCEEDED WITH CONTRACTS TO VENDORS FOR SOME HARDWARE AND ALL SOFTWARE AT ITS OWN EXPENSE, WE HAVE STARTED WITH PHASE II DEVELOPMENT WITH AGREEMENT TO CHARGE TO THE EXISTING PHASE II CONTRACT,

EXPECTED OCT '79

IPD HARDWARE CONFIGURATION

- COMPUTER - INTERDATA 3220
- GRAPHICS DISPLAY - TEKTRONIX 4081
- HARDCOPY - VERSATEC 8224

PROJECT PLAN
PHASE. II.

		MONTH OF COMPLETION FROM START OF PHASE
*	• ISSUE PURCHASE ORDERS.	1
	• INTERDATA TRAINING	3
*	• DEFINE DATA SPECIFICATION	5
*	• AD 2000 INTERFACE	5
	• WRITE HOST ROUTINES	7
	• HARDWARE/SOFTWARE INSTALLATION	7
	• RJE INTERFACE	7
(10/79)*	• AD 2000 INSTALLATION	9
(10/79)*	• AD 2000 TRAINING	10
	• MINI SEND/RECEIVE	12
	• REFINE NEST	14
	• REFINE NORMS	25
	• TABLES	19
	• SHOP DRAWING CAPABILITY	‘20
	• REFINE PARTS DEFINITION	20
	• DOCUMENTATION	23
	• WORKSHOP	24

*INDICATES WORK ALREADY IN PROGRESS

SHIPBUILDING STEEL - UNITED STATES VS. JAPANESE PHILOSOPHIES

Gene Mayer
Engineering Hull Section Chief
Levingston Shipbuilding Company
Orange, Texas

As Engineering Hull Section Chief, Mr. Mayer is currently in charge of the Hull structural, outfitting and material groups for the design development of both commercial and offshore shipbuilding projects. Other responsibilities include Chairmanship of the SPADES Users Steering Committee.

Mr. Mayer attended Lamar University in Beaumont, Texas. He has over 18 years experience in all phases of shipbuilding engineering.

INTRODUCTION:

The United States, with the steady decline in commercial and naval shipbuilding, is not able to command the respect of the steel producer of this country that is afforded the Japanese shipbuilding industry by its steel producers. This is shown by a lack of shipbuilding structural shapes with the Japanese able to use a wide array of structurals while the U.S. is restricted to using split wide flanges and angle; the largest shapes being, 9" x 4" rolled by mills only once a year.' Even the bulb plate; a standby of the industry, is no longer produced in the U.S.

This alone contributes to the greater cost of building ships in the U.S. without the help of political apathy, declining productivity, and a lack of modernized shipbuilding facilities.

I have often heard that in the United States there is more steel produced each year for drink cans than for building ships. This, of course, is somewhat of an exaggeration as the U.S. steel industry is a leader in the world production of steel. Unfortunately, too little of this steel is produced for the U.S. shipbuilding industry and according to the "Marine Engineering Log", June issue, in an article by Gene Heil, the overall prospects are hazy with much uncertainty in the government sector concerning our military and commercial shipbuilding industry. Although our shipbuilding industry is in a decline in some sectors with about 2.6-million gross tons, so is the rest of' the worlds, with Japan still in the lead with 6.2-million gross tons on the order book. This brings us to the subject at hand, "SHIPBUILDING STEEL U.S. VS. JAPANESE PHILOSOPHIES".

First let us examine the facts of steel production and its relationship to the shipbuilding industry in each country. Consider a year like 1978 (not the best for overall shipbuilding); lets compare the production of steel of each country and the percentage of the overall steel production used in the commercial shipbuilding industry. (See Fig. #1). The total amount of steel produced in the U.S. and Japan was over 100-million short tons through-put by each of the countries steel mills. (From "Iron Age" magazine, I.H.I. Data Book and "World Book Encyclopedia'). Japan completed about 6,3-million gross tons of ships (over 100 gross tons) to the United States 1.03-million gross tons. This small percentage leaves the U.S. shipbuilding industry very little influence over steel producers in the U.S. This is not to say that the steel industry isn't happy with our business, however, it is unfortunate that the U.S. shipbuilding industry is not strong enough to command the respect which is offered to our Japanese counterparts.

To illustrate some items that the shipbuilding industry of Japan has which are unavailable in the U.S., we need to consider the structural shapes produced by each country that lend themselves to shipbuilding. (See Fig. #2). First are the angles with the U.S. peaking out at an 8" x 4" with a rare 9" x 4" at the top. The Japanese mills offer a wide variety of angle type shapes up to 15" or 16" in depth and with varying thickness between the web and flange. These shapes remind me of the channels which were modified by cutting off a flange that is so often used in the barge building industry.

Consider the problem of ship bottom construction of a parallel midbody area. In order to be economy minded it is best to use the widest spaced longitudinals and the widest plates possible in order to reduce fitting and welding. In the

U.S. you are limited by a 9' high heavy angle, a modified wide flange shape, a fabricated structural member or import an appropriate shape if policy (Jones Act 1920) permits such; For example, the "FUTURE 32" ship of I.H.I. design, under construction at Levingston shipbuilding, in Orange, Texas, was originally designed with bottom and interbottom structurals of metric angles 250 x 90 x l0/15 (10 x 3 l/2 x 3/8 / 9/16). Structurals as these are ideal as they offer relative light weight (22.6 #/Ft.) for the section modulas produced (32.95 in^3).

The replacement was a tee section of 9 x 20#-which was lighter but created additional fitting and welding as illustrated in Fig. #3, The construction arrangement using tees is expensive using about 3500 feet of weld just in the innerbottom over what was required in an exact shipbuilt in Japan. Even the old bulb plate cannot be found in the U.S., so the substitute was heavy slabs with round bar welded to the edge for the main deck construction. Of course, other alternatives are available such as built up members and flanged plates as shown in Fig. #4. Most of the alternatives are expensive for they involve additional man-hours not required with better structural sections.

Recently (late July, 1979), I had the privilege of visiting a shipyard in Aioi, Japan, of the I.H.I. complex. I.H.I. Aioi Shipyard is impressive with good equipment that is hard pressed to be equaled in the U.S. and is somewhat typical to other Japanese shipyards except for the exception of having plenty of work. I expected to see rows and rows of purchased steel in their stock yard since they can build a 40,000 DWT tanker from fabrication start to delivery in eight (8) months -- (shades of U.S. World War II shipbuilding production). Was I ever wrong, for they maintain only two or three day steel stock and they receive steel every other day. The I.H.I. complex does not own a steel.mill as some Japanese shipyards do. These plates are <u>bought and delivered to the exact size needed</u> at the exact time needed for fabrication start.

Steel plates produced for the Japanese shipbuilding industry are rolled to the exact size needed. The scrap is held to a minimum of five mm (3/16") at each edge (from J.I.S. handbook interpretation by I.H.I.'s H. Kurose). Often for shell plating the exact size is requested and delivered. This is what the I.H.I. shipyard complex calls sketch sizes and are purchased and received exactly as the sketches call for. Plates bought under this system can often be used, depending upon thickness, without any additional preparation for welding and fitting. Contrasted to the steel plates bought from U.S. mills with stocked 2" in width and 3" in length for the purpose of squaring up. (See Fig. #5).

Another service the Japanese mills provided was to ship structurals which were blasted and pre-primed. This service is provided by all of the three or so steel mills the I.H.I. Aioi Shipyard use for their purchases. These shipments are all by water in small self-propelled ships which are tailored for this purpose. The steel is off-loaded and according to markings provided by the steel mill is sent directly into the fabrication area where it is needed whether directly to the photo electro marking process, numerical control burning machines, or to the many fabrication areas.

Many yards in the U.S. buy steel for the whole job or jobs when possible which is due to many reasons such as mill rolling schedules, price fluctuation and lead times. Many U.S. shipyards have very good material handling systems such as the N/C directed system in use at Avondale but they have to maintain a considerable amount of steel stocks. Some U.S. shipyards like the Japanese yards contract with the steel mills for so much tonnage per year. But, during the last U.S. steel shortage it was the shipyards who often suffered and not the appliance, automotive, farm equipment and construction equipment industries.

The philosophies of shipbuilding steel are not confined only to the ability to purchase steel but also to the processing of steel. In the U.S. many shipyards are still utilizing a system of transverse framing when getting into the shaped portion of a ship in the bow and stern. At least most utilize a system of transverse bilge framing and electing to bend only in one plane finding twisting longitudinal framing often too difficult. The I.H.I. Aioi Shipyard as well as most Japanese shipyards use a longitudinal framing system extending into bilges and to the bow and stern. This involves an uncomplicated system of using an inverse curve frame bending program and twisting the longitudinal members with direct heating which fixes the correct shape into each member. This system is much less costly than using the transverse framing system with all of its end connections and shaping required. Also, using the pre-shaped longitudinals lends itself to the next amazing usage of steel which was observed at the I.H.I. Aioi Shipyard. Steel plates are cut by the N/C burning machine after marking and shaped by a process called flame bending and shaping. Of course, some mechanical bending by hydraulic press and rolls is utilized just the same as with the U.S. shipyards. The more complicated shapes, like as used in bulbous bows, and bulb type sterns are put into plates by a process of heating and water quenching which can move plates into the correct shape desired. This method of construction is much less costly than other methods and often the use of an expensive casting can be avoided.

As to the cost of shipbuilding, U.S. versus Japan, in the recent article in the magazine, "The American 'Shipper", June issue, by Tim Colton, it pointed out the differences in time and cost in construction of identical ships. The 32,000 DWT bulk carriers of the I.H.I. "FUTURE 32" design. It was shown that Japan in the I.H.I. Aioi Shipyard could build the ship in 12-months at a cost of $20-million, while the same ship will take 26-months and $40-million to build in the U.S.,

Levingston Shipyard. This can't all be attributed to the differences in shipbuilding steel philosophies as it is a much more complicated study.

Also, when speaking of shipbuilding cost the subject of subsidies and cheap labor often arise when comparing U.S. and Japanese shipbuilding. While the Japanese often build ships for the export market foregoing their profit (which is made up in their domestic market) they do not directly subsidize their shipbuilding industry but offer an indirect subsidy in the form of investment tax credits and such just as with most of the world shipbuilding industry. Only the U.S. has a direct method under the Merchant Marine Act of 1970 for a construction differential subsidy (CDS). Also, Japanese workers are as well paid and provided for as their U.S. counterpart. The amazing thing is the productivity ratios of the two nations which is where most of the Japanese success is to be had. The U.S., in the first quarter of 1979, registered 60.3-million metric tons of steel shipped. (Example #6). The shipbuilding industry had orders placed for about 4-million deadweight tons of vessels which is about 1-million tons of steel. This is not enough to make the steel industry leap with joy as they are only running at about a 75-percent capacity. This will further erode our possibilities of getting the specialized shipbuilding structural steels so often needed in our industry.

CONCLUSION:

The shipbuilding industry in the United States needs the specialized shipbuilding steel structurals and shapes in order to turn the tide to become once again "Master" of the seas. I heard the unsubstantiated rumor that during a recent military maneuver to overseas ports some of the U.S. military equipment had to be shipped on foreign ships due to the U.S. having too few of the ship types necessary to do the job. Also, according to the July "Boilermakers Blacksmiths" reporter, Harold J. Buoy, Metal Trades Council International President said, "We must make the United States the number one shipbuilding nation in the world." "We have a common goal -- what shipyard worker's need, America needs." It is a matter of economics as to why the U.S. steel mills do not produce proper structural shapes as do the Japanese steel mills. But, when the needs of our nation are so critical for strong maritime and naval fleets, we will need and hopefully have, much to the delight of the steel and shipbuilding industry, the raw-materials to do the job, which is to "PUT THE U.S. BACK IN THE NUMBER ONE POSITION IN THE WORLD".

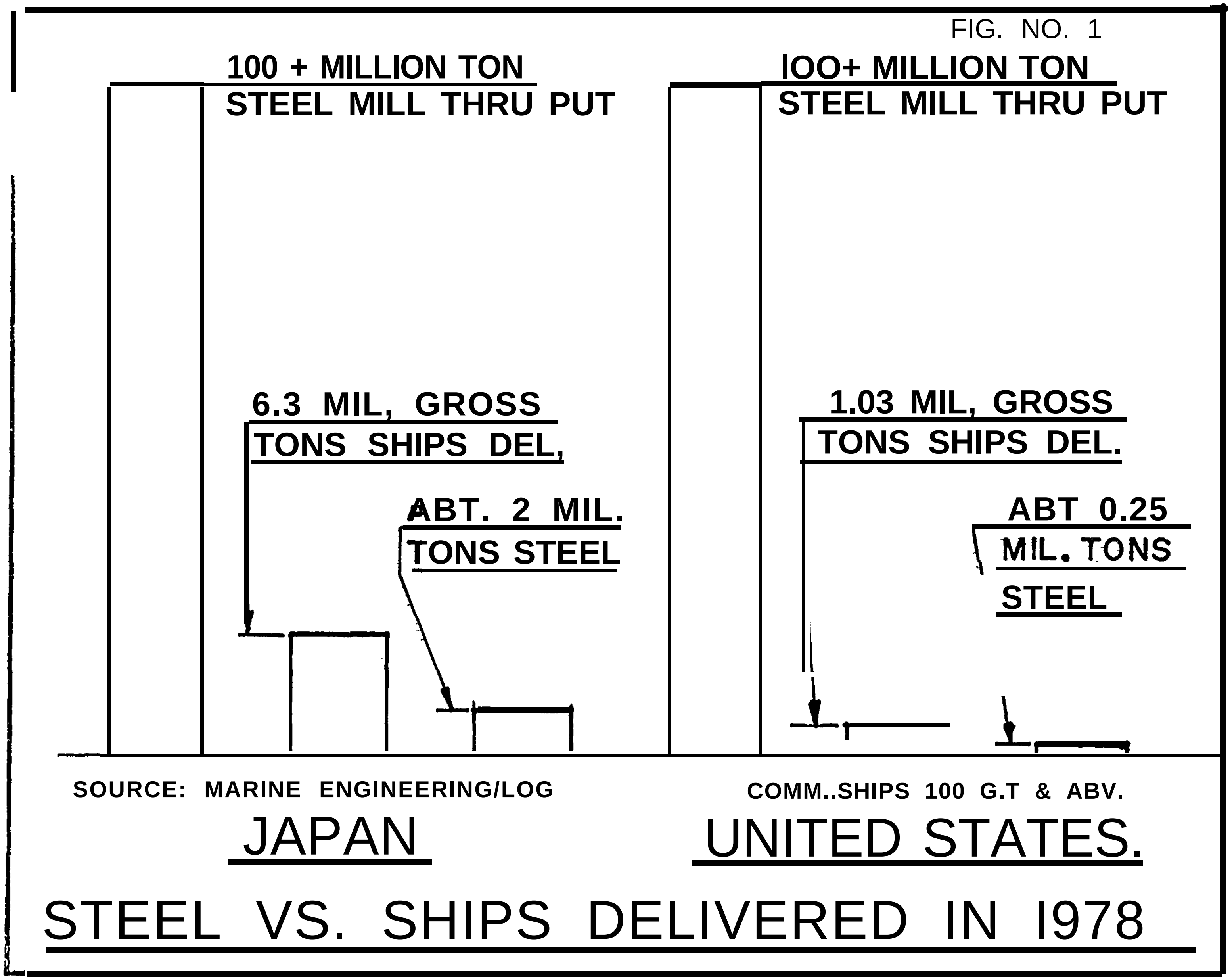
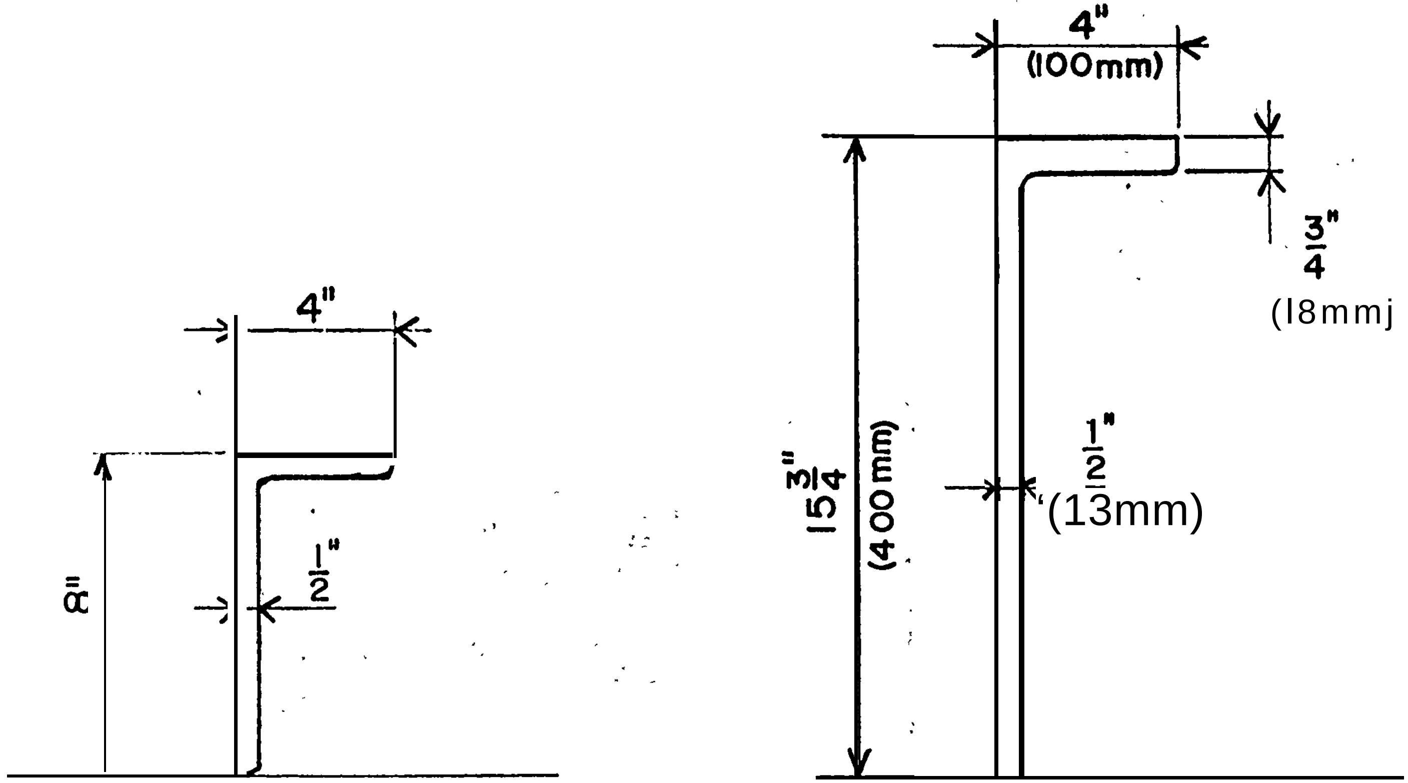


FIG. NO. 1
100 + MILLION TON
STEEL MILL THRU PUT
IOO+ MILLION TON
STEEL MILL THRU PUT
6.3 MIL, GROSS
TONS SHIPS DEL,
ABT. 2 MIL.
TONS STEEL
1.03 MIL, GROSS
TONS SHIPS DEL.
ABT 0.25
MIL. TONS
STEEL
SOURCE: MARINE ENGINEERING/LOG
COMM..SHIPS 100 G.T & ABV.
JAPAN
UNITED STATES.
STEEL VS. SHIPS DELIVERED IN I978



U. S. STRUCTURAL

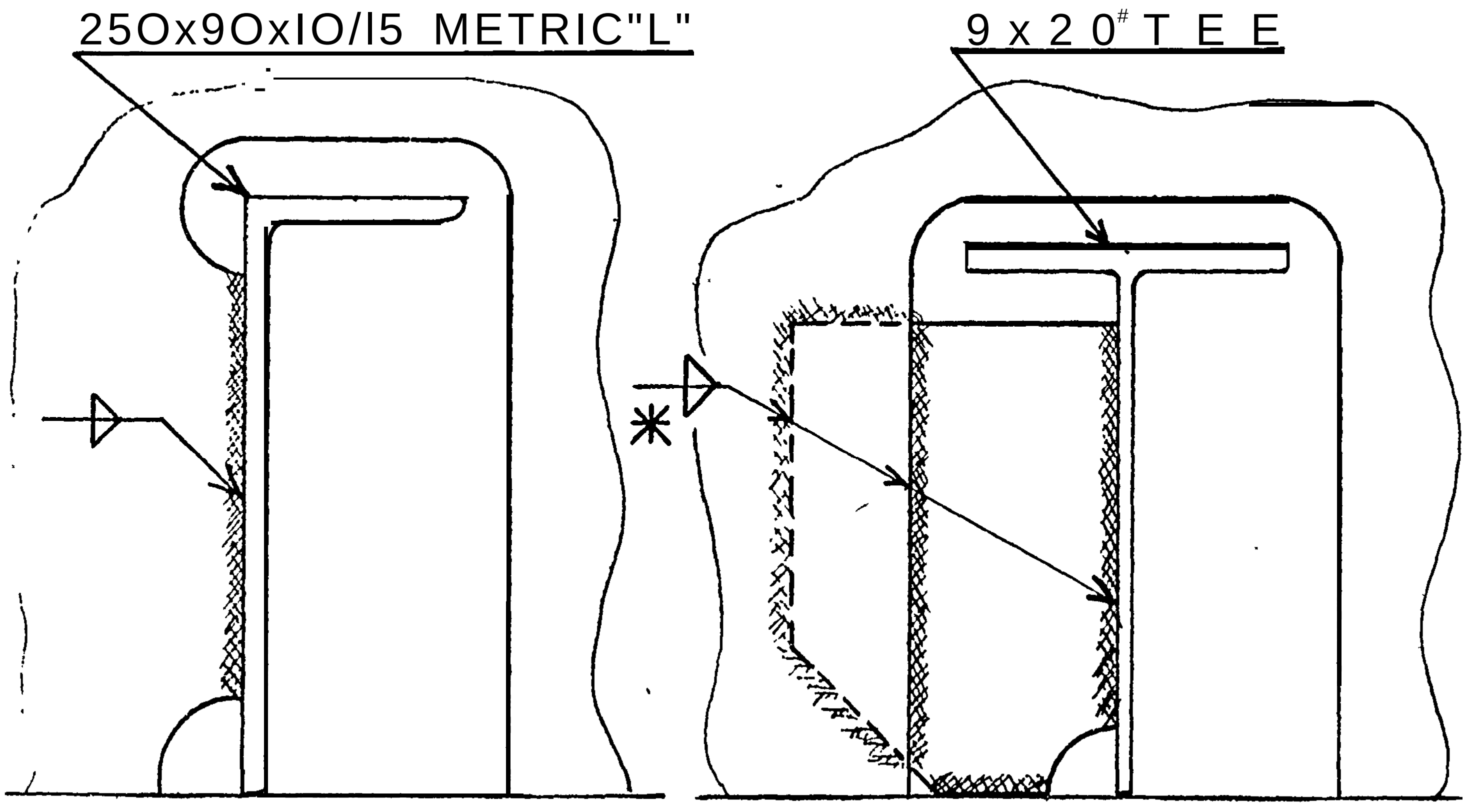
TO 9x4x I

JAPANESE

FROM 200x90mm(8"X3.5")

TO 400 mm x IOOmm (153/4"X4")

FIG. NO. 2

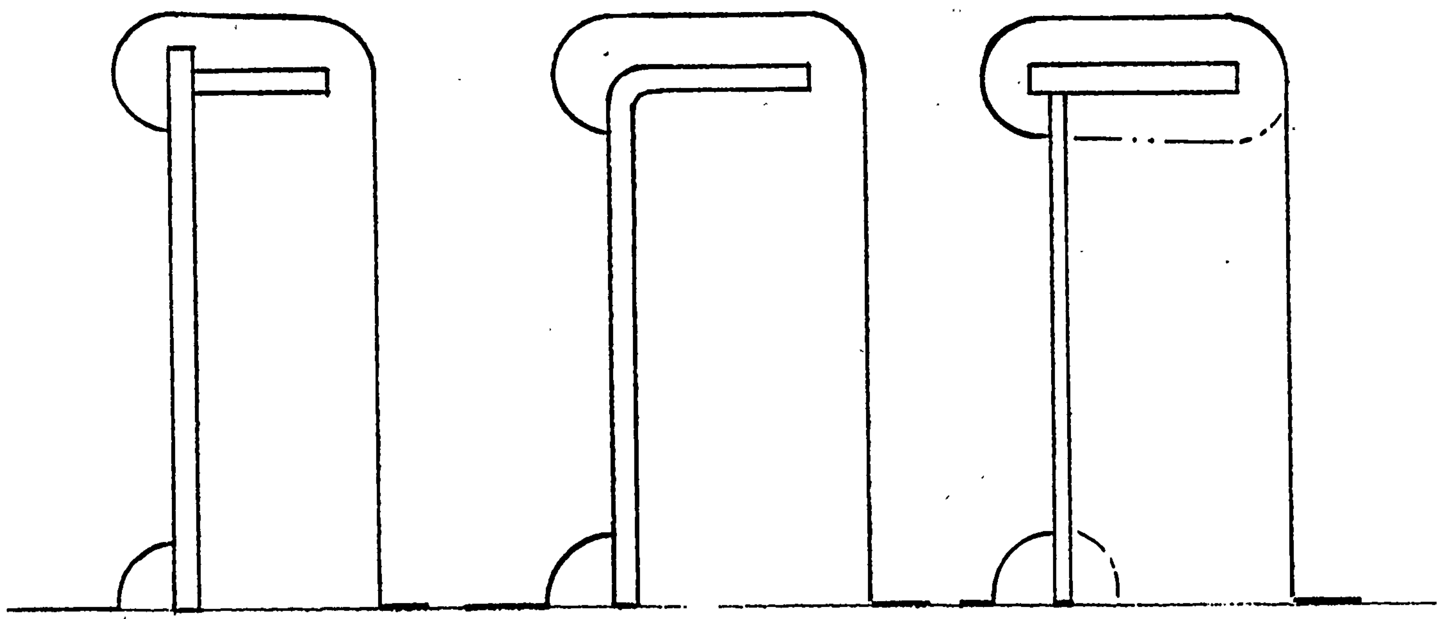


USED AT IHI AI01 SHIPYARD

SUBSTITUTION AT LEVING STON

* 3500'-0" ADDITIONAL WELDS IN MIDBODY BOTTOM a STRUCTURE

FIG. NO. 3



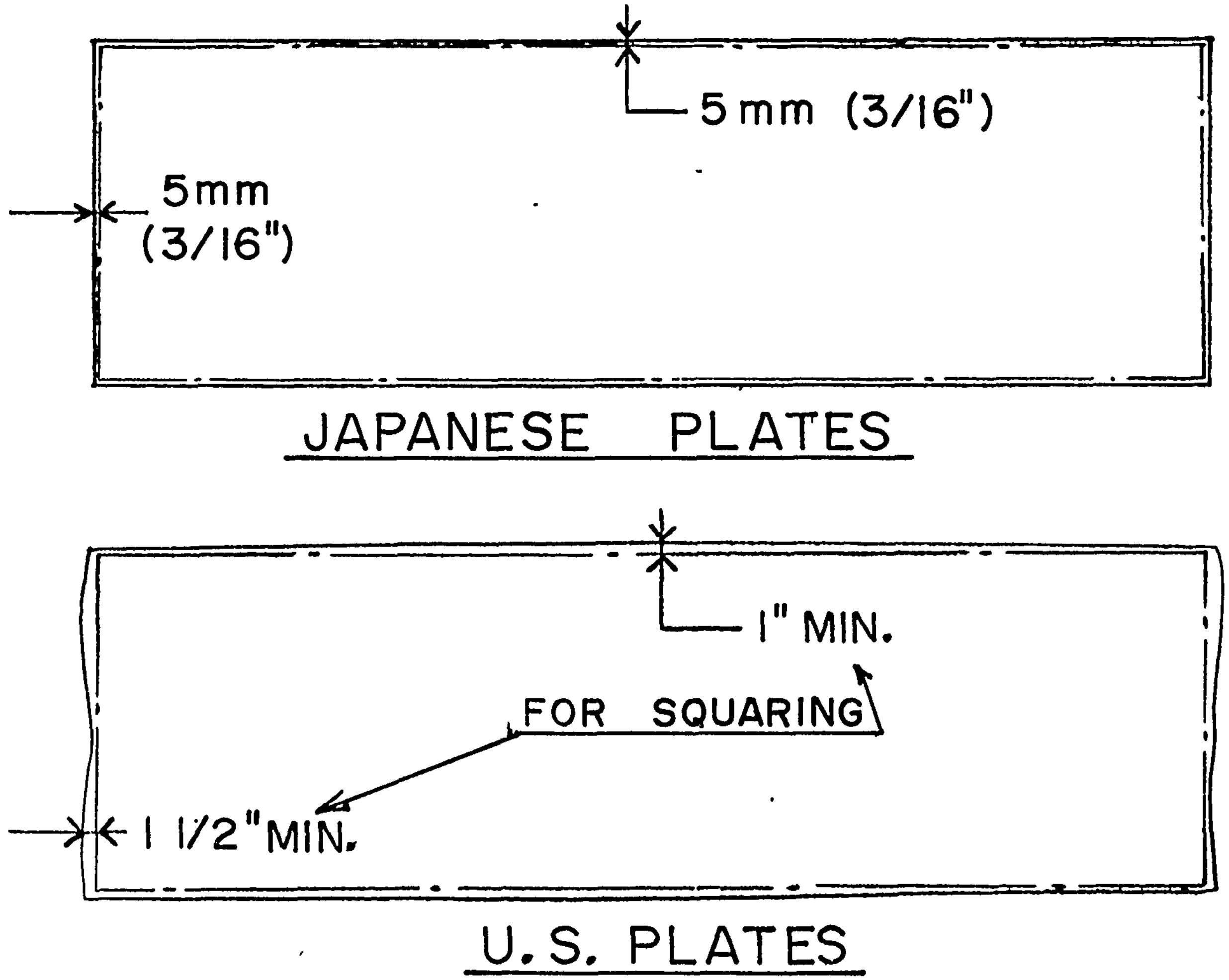
BUILT - UP ANGLE

FLANGE PL

OFFSET FLG. TEE

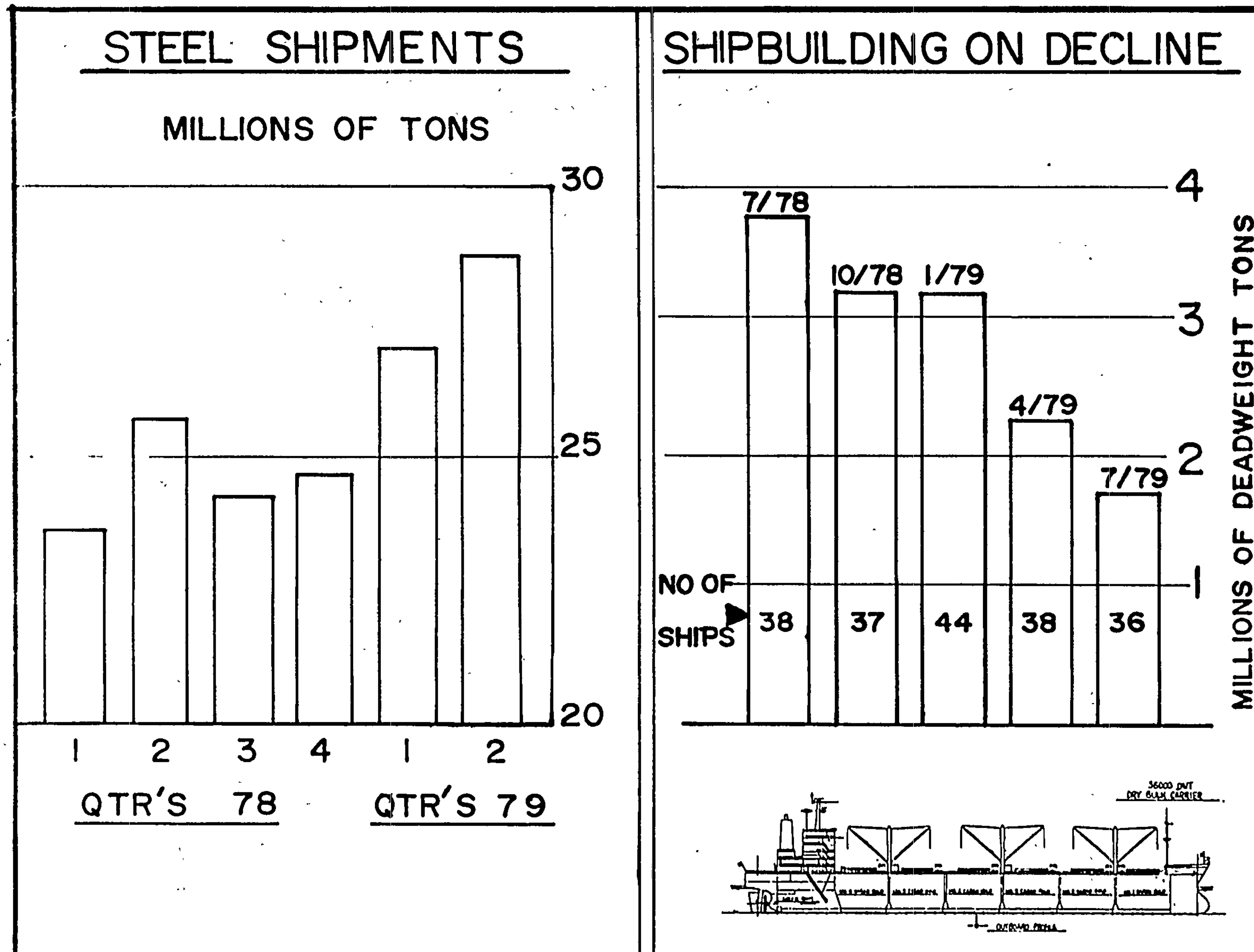
ALL REQ. ADD. MANHOURS TO FABRICATE

FIGURE NO.4



COMPARISON OF PLATES AS SHIPPED

FIG. NO. 5



SOURCE : AISI AND IRON AGE AUG. 6, 1979 FIG. NO. 6

ICCAS '79 HIGHLIGHTS

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Mr. Moore is currently the Newport News REAPS technical representative, the Project Manager of the low cost parts definition project, and is a member of a structural CAD/CAM project. He received his degrees in naval architecture and marine engineering from the University of Michigan. Together with Doug Martin, he authored the paper, "Requirements and Benefits of Integrated Computer Aided Ship Design and Production" presented at ICCAS 79.

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ICCAS '79

INTERNATIONAL CONFERENCE ON COMPUTER APPLICATIONS IN THE AUTOMATION OF SHIPYARD OPERATION AND SHIP DESIGN, III,

UNIVERSITY OF STRATHCLYDE, GLASGOW, SCOTLAND

JUNE 18-21, 1979

TOPICS

- GENERAL TOPICS IN SHIP TECHNOLOGY
- COMPUTER AIDED SHIP DESIGN
- COMPUTER AIDED SHIP PRODUCTION
- INFORMATION SYSTEMS FOR SHIPBUILDING'
- GRAPHICS AND COMMUNICATIONS' IN SHIP TECKNOGY
- WORKSHOP SESSIONS'
    - EFFECTIVENESS AND ECQNOMICS OF COMPUTING
    - DESIGN AND IMPLEMENTATION OF COMPUTER AIDED SYSTEMS,
    - COMPUTER ASSISTED TEACHING/TRAINING
    - MANAGEMENT OF CHANGE

PAPERS COMMON TO ICCAS '79 AND CURRENT SYMPOSIUM

- REQUIREMENTS AND BENEFITS OF INTEGRATED COMPUTER AIDED SHIP DESIGN AND PRODUCTION,

  D. J. MARTIN/R, C, MOORE

- SCAFCO, A CAD AND CAM INTEGRATED SYSTEM FROM BASIC DESIGN TO ASSEMBLY,

  R. DI LUCA/E. BAIS

- INTERACTIVE AUTOKON: FOCUSSING ON THE INFORMATION SYSTEM,

  J. F. MACK/J. ØIAN/P. SORENSEN

- NEW CONCEPTS AND DP SYSTEMS ARCHITECTURE IN HULL DETAIL DESIGN,

  P. BANDA

PAPERS OF INTEREST

- INTERACTIVE DESIGN OF FAIR HULL SURFACES USING B-SPLINES.

  MUNCHMEYER/SCHUBERT/NOWACKI

- SHIP SURFACE DESIGN BY TRANSFORMING GIVEN MESH REPRESENTATIONS,

  RABIEN

- COMPUTER SYSTEM FOR SHIP PROPULSIVE PERFORMANCE,

  OGIWARA/NAMIMATSU/OCHI/MORI

- A PROGRAM SYSTEM FOR STRENGTH AND VIBRATION CALCULATIONS FOR SHIP STRUCTURE,

  PEDERSEN/JENSEN

- CAD CAM IN FRENCH SHIPYARD,

  ESNIS

- AN ASSOCIATIVE RING STRUCTURE FOR ALLEVIATING SPATIAL INTERFERENCES,

  NEHRLING

- GERMANISHER LLOYDS DATA BASE FOR SHIP STRUCTURAL DATA,

  KAUBE

- CONCISE DESCRIPTION AND AUTOMATIC FINITE ELEMENT MODELLING OF SHIP STRUCTURES WITH "DEMAIN".

  DE CASTEL/FINIFTER

- NESTING OF MORE THAN A LAYOUT PROBLEM,

  SPERLING

- PANSY, AN ADVANCED INTERACTIVE PARTS NESTING SYSTEM,

  IKEDA

- HUMAN CONSIDERATIONS IN SHIP PRODUCTION AND SOME EXAMPLES OF COMPUTER AIDED FACILITY,

  FUJITA/SUNAGAWA

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(CO679-006)	ON-LINE SURVEY STATUS AT AMERICAN BUREAU OF SHIPPING K.M. Mole, W.L. Newton 111
(CO679-007)	ON THE ACTIVITIES OF SYSTEMS TECHNOLOGY AND COMPUTER APPLICATION COMMITTEE IN SHIPBUILDING (SCCS) OF JAPAN Y. Akita, J. Suhara, Y. Fujita
(co-20679-008)	COMPUTER SIMULATION MODELLINGS FOR SHIP DESIGN STUDIES K.J. MacCallum
(CO679-009)	INTEGRATED COMPUTER SYSTEMS FOR WEATHER BOUND VESSEL OPERATIONS G.L. Petrie, D. Hoffman
(CO679-010)	A MODEL FOR THE REALISTIC EVALUATION OF SHIP INVESTMENT AND OPERATION C.V. Kakamoukas
(*0679-011)	REQUIREMENTS AND BENEFITS OF INTEGRATED COMPUTER AIDED SHIP DESIGN AND PRODUCTION D.J. Martin, R.C. Moore
(CO679-012)	INDES - A CONVERSATIONAL INFORMATION SYSTEM FOR PRE-CONTRACT SHIP DESIGN F. Spincic, B. Rosovic, S. Crnjaric
(0679-013)	INTERACTIVE DESIGN OF FAIR HULL SURFACES USING B-SPLINES F.C. Munchmeyer, C. Schubert, H. Nowacki
(CO679-014)	INTERACTIVE PROGRAM FOR THE DESIGN OF SHIP HULL FORMS I.M. Yuille
(CO679-015)	SHIP SURFACE DESIGN BY TRANSFORMING GIVEN MESH REPRESENTATIONS U. Rabien
(CO679-016)	SHIP HULL DEFINITION BY SURFACE TECHNIQUES FOR PRODUCTION USE K. Izumida, Y. Matida
(*0679-017)	COMPUTER AIDED DESIGN OF SHIPBOARD ELECTRICAL INSTALLATIONS P.M. Attwood
(CO679-018)	PROGRAM SYSTEM FOR MULTI-VARIANT‘ RECONTRACT SHIP POWER PLANT DESIGN M. Wesolowski, A. Jeziorski, M. Molewicz, B. Rozpedek
(CO679-019)	COMPUTER SYSTEM FOR SHIP PROPULSIVE PERFORMANCE S. Ogiwara, M. Namimatsu, M. Ochi, M. Mori
(CO679-020)	METHODS OF OPERATIONS RESEARCH IN CAD SYSTEMS EXEMPLIFIED BY SHIPS J.A. Jagoda
(CO679-021)	A PROGRAM SYSTEM FOR STRENGTH AND VIBRATION CALCULATIONS FOR SHIP STRUCTURES P.T. Pedersen, J.J. Jensen

Reaps Library Number	Title and Author(s)
(C0679-022)	TORSION OF SHIPS WITH LARGE DECK OPENINGS H.S.Y. Chan
(C0679-023)	EXPERIENCES WITH SMD - A CAM-PROGRAM PACKAGE ON MINICOMPUTERS B. Arndt
(C0679-024)	THE LINK BETWEEN DESIGN AND THE PRODUCTION PROCESS ASSOCIATED WITH SHIPBOARD PIPEWORK SYSTEMS R.A.M. Hunt
(C0679-025)	INTEGRATED COMPUTER AIDED DESIGN AND SHIP PRODUCTION SYSTEMS H. Arnold, R. Brunner, J. Blackshaw
(*0679-026)	THE DEVELOPMENT OF A 3-DIMENSIONAL MODEL TAKE-OFF SYSTEM K.W. Nichols, D.E. Gilbert, M.R. Smith
(C0679-027)	PRACTICAL EXPERIENCES WITH SEMIAUTOMATIC AND AUTOMATIC PART-NESTING METHODS D. Bohme, A. Graham
(*0679-028)	SCAFO, A CAD AND CAM INTEGRATED SYSTEM FROM BASIC DESIGN TO ASSEMBLY R. Di Luca, E. Bais
(C0679-029)	MANAGEMENT INFORMATION SYSTEMS FOR SHIPYARDS IN THE 80'S B.B. Lindberg
(C0679-030)	THE MANAGEMENT INFORMATION SYSTEM FOR U.S. NAVAL SHIPYARDS, DESIGN FOR THE FUTURE J.A. Sisson
(C0679-031)	AN ASSOCIATIVE RING STRUCTURE FOR ALLEVIATING SPATIAL INTERFER-ENCES B.C. Nehrling
(*0679-032)	ON-LINE SHIP PRODUCTION CONTROL SYSTEMS T. Devenport, R. Smith
(C0679-033)	NK SHIP MAINTENANCE INFORMATION SYSTEM S. Sato, N. Hikasa
(C0679-034)	WORKSHOP LEVEL INFORMATION SYSTEM OF THE STEEL STRUCTURE PRODUC-tion S. Gotz
(C0679-035)	GERMANISCHER LLOYD'S DATA BASE SYSTEM FOR SHIP STRUCTURAL DATA R.K. Kaube
(C0679-036)	CONCISE DESCRIPTION AND AUTOMATIC FINITE ELEMENT MODELLING OF SHIP STRUCTURES WITH "DEMAIN" J. de Castel, D. Finifter

Reaps Library Number	Title and Author(s)
(CO679-037)	NESTING IS MORE THAN A LAYOUT PROBLEM B. Sperling
(CO679-038)	TOLERANCE-DEPENDENT MODELLING APPROACH FOR CURVE MANIPULATION T.A. Ommundsen
(CO679-039)	USE OF STANDARD TV CAMERA TO DIGITISE LINE DRAWINGS R. Gray, G.K. Henderson, C.B. Besant, A.G. Eagles
(CO679-040)	THE PANSY, AN ADVANCED INTERACTIVE PARTS NESTING SYSTEM Y. Ikeda
(CO679-041)	NEW CONCEPTS AND D.P. SYSTEMS ARCHITECTURE IN HULL DETAIL DESIGN P. Banda
(CO679-042)	AN INTERACTIVE GEOMETRY PROCESSOR FOR DETAIL DESIGN AND PARTS DEFINITION M.M. Parker, A.F. Westrop
(CO679-043)	HUMAN CONSIDERATION IN SHIP PRODUCTION AND SOME EXAMPLES OF COMPUTER AIDED FACILITY Y. Fujita, Y. Sunagawa
(*0679-047)	NEW DIMENSIONS IN MAN-MACHINE COMMUNICATIONS F.M. Lillehagen, R.F. Riesenfeld, S. Frogner

The complete set of preprints for ICCAS '79 can be ordered from Elsevier North-Holland Inc.,'52 Vanderbilt Ave, New York, NY 10017. Reference C. Kuo, et al, "Computer Application in the Automation of Shipyard Operation and Ship Design III". Price $73.25.

* Abstract published in REAPS Technology Bulletin, Volume 6 Number 2, August 1979.

EXPLOITING DBMS IN SHIPBUILDING

Special Interest Group Meeting Report

O.J. Wolanyk
Manager, Information Systems Administration
National Steel and Shipbuilding Company
San Diego, California

As Manager of Information Systems Administration, Mr. Wolanyk is responsible for data base administration, word processing, standards, and procedures. He is a graduate of the University of Akron with two degrees in mathematics.

Mr. Wolanyk previously served as Data Base Manager at Sherwin-Williams and as Data Base Administrator at NASA-Lewis Research Center.

SPECIAL INTEREST GROUP MEETING REPORT:

Exploiting Database Management Systems in Shipbuilding

O.J. Wolanyk

The thought occured to me while sitting here listening to these excellent presentations that those of you who were in the SIG session yesterday concerned with defining data processing problems missed our session which was involved in solving them.

Our basic discussion was on database administration, starting out by defining data as a corporate resource that should be managed, mainly because it costs money. It costs money to manipulate it, it costs money if you cannot access it. We talked about today's environment in data processing as being fragmented, characterized by the lack of controls - the usual syndrome of everybody wanting to own their own data.

We raised the question of why should a corporation consider their own database. The main reason, of course, is to gain control over the data and therefore improve the accuracy and the timeliness of the data. That is, to be able to retrieve information and know that it is the most accurate and up to date available. Other reasons are to reduce data redundancy and thereby permit sharing of data among applications and allow data usage restrictions to be applied effectively. Knowing where the data is located, or that it resides in fewer locations, makes it easier to control that data. Finally of course, maintenance of data integrity and data independence issues can be addressed. By data independence issues we mean the ability to change a program or to change a database and not have to change the other.

We discussed data administration tools that are available to us. Specifically, the database management system and the data dictionary. A data dictionary is a central repository of information containing standardized descriptions of data and other components of information systems. The theory being that if we can document existing systems we will be in good position to take advantage of upcoming technology, instead of doing the usual routine of trying to figure out where we are today. The objectives of the data dictionary itself, are to prevent unplanned redundancy and inconsistency in data, to know where the data are and to take advantage of it rather than recreating it each time. More importantly, through the data dictionary facilities a reduction in application development cost and time can be realized. Applications can be finished sooner, because they can be started sooner; a reduction in application modification costs and time can be realized.

We all know program maintenance is the most significant part of most data processing budgets. We can support the establishment and enforcement of database standards again through the centralized control the data dictionary capability will give us. Furthermore, we will have a vehicle that will facilitate communication between the using community and data processing. The questions that the data dictionary can answer for us, that we need to know at system development time include: What data are available in the corporation? Where is the data located? How is it structured? Who is responsible for it? Who are the users and where are they located? And what are the reports and programs which use that data? If we have that information at hand then changes in the corporation's way of doing business and the way of doing manufacturing can quickly be reflected in changes to the underlying data processing systems that support those functions.

Two major conclusions were arrived at during the session. First, there are no database management system packages commercially available today that really suit both the commercial and the manufacturing side of an organization as well as the engineering side. However, there is a commonality between the two application *areas* that should be tied together, perhaps, through interface systems. The second conclusion is that the effort involved in the implementation of a data dictionary is worth it to put the shipyard in position to take advantage of new technology.

PLANNING AND PRODUCTION CONTROL FOR SMALL AND MEDIUM SIZE YARDS

Special Interest Group Meeting Report

James S. Sligar
Director of Manufacturing Services
Jeffboat Incorporated
Jeffersonville, Indiana

As Director of Manufacturing Services, Mr. Sligar is currently responsible for the accounting, industrial engineering, purchasing, material control, planning and scheduling, warehouse and steel yard.

Mr. Sligar holds degrees in electrical engineering from West Virginia University, and engineering and business administration from M.I.T. He has 25 years of experience in shipyard and factory management in metalworking, fabrication, and construction.

SPECIAL INTEREST GROUP MEETING REPORT:

Planning and Production Control for Small and Medium Size Yards

J.S. Sligar

Following the introduction of the individuals and the yards attending the meeting, the purpose of the meeting was explained. The meeting was to provide an informal forum for people with common interests to exchange ideas and experiences within a particular area. There were 10 to 12 yards participating in the discussion. Areas of common interest discussed included:

Work measurement standards and their application; Two of the yards Dresent will participate in the upcoming funded program to develop methods for developing predetermined shipyard standards for skills common to shipbuilding.

The application and use of work packages for labor, material control, and scheduling purposes.

Numerical control application and techniques.

Computer application other than Business and Accounting. The use of computers in small and intermediate yards for business purposes is an accepted practice. There was, and is, much interest in computer application for labor control, performance to budget or plan information, manage ment information, and technical numerical control application.

'The discussions were good. Experiences, questions, and the exchange of ideas were beneficial. It was the consensus of yards attending that the meeting was worthwhile and should be continued at future REAPS Symposiums.

COMMON SHIPYARD INFORMATION SYSTEM AND DATA PROCESSING PROBLEMS

Special Interest Group Meeting Report

Donald A. Spanninga
General Manager
Information Systems Department
National Steel and Shipbuilding Company
San Diego, California

Mr. Spanninga is currently responsible for directing the design, development, implementation and support of information systems at NASSCO.

He has a degree in industrial management and an MBA from Michigan State University. The majority of his 13 years background in information systems and data processing was spent in dealing with manufacturing systems. He has had primary responsibility for design development and implementation of a variety of systems, including bill of material, inventory control, product costing, service parts, payroll, labor distribution and manufacturing planning systems.

REAPS SYMPOSIUM - SAN DIEGO, SEPTEMBER 12, 1979

SPECIAL INTEREST GROUP MEETING REPORT:

Common Shipyard Information System and Data Processing Problems

D. Spanninga

Over 40 people attended the discussion group titled "Information Systems and Data Processing Problems." There were seven shipyards represented as well as several areas within the Navy and a few other organizations. The yards represented ranged from small organizations with only about 30 people in data processing to very large organizations with over 200 people in data processing and a budget greater than $20 million per year for data processing services.

Six out of the seven yards represented stated that they had two or more IBM systems in their data processing organizations. Other systems mentioned were a Univac, a Honeywell and some mini-systems for unique applications.

The major topics discussed were justification of projects, setting of project priorities, and user involvement in the design, development, justification, and setting of priorities for projects. All of the shipyard representatives commenting on these topics were in agreement that the user organizations must be involved in all phases of system development. Most seem to agree that the user must be the one to justify and prioritize the projects and that the analysts must work closely with the users through each step of the design and development of a project, even to the point of getting the user to approve each step through a formal sign-off procedure.

The General Dynamics Electric Boat representative discussed their management mechanism for budgeting the data processing dollars. He explained that within the EB user community they had developed what is called system's management. That is, they have assigned high level management people in the user areas as system managers to allocate the data processing manhours and processing costs for his assigned area of responsibility.

A question asked the representatives was "what was the major thrust or direction of the Information Systems resources in the next year or two?" Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) was a consistent response, though varying degrees of both sophistication and direction existed. There were some responses also in the area of manufacturing control and planning systems.

No major conclusions were drawn other than that more communications between the Information Systems and Data Processing function of the various organizations represented was considered desirable. It was suggested that the REAPS organization be used as a vehicle to support additional communications, and that further meetings be held in conjunction with the annual symposium, and separate meetings under REAPS auspices.

APPENDIX A: REAPS TECHNICAL SYMPOSIUM AGENDA

TUESDAY, SEPTEMBER 11

8:OO -3:30 REGISTRATION **FOYER**

9:oo GENERAL SESSION **STARDUST ROOM**

WELCOME
A. S. Giorgis, National Steel & Shipbuilding Co.

THE REAPS **PROGRAM: PROGRESS TO DATE**
J. R. Vander Schaaf. IIT Research Institute

ALTERNATIVES FOR EFFECTIVE CAD/CAM UTILIZATION
B. J. Breen. General Dynamics/Data Systems Services

10:30 INFORMAL DISCUSSION PERIOD

II:oo GENERAL SESSION **STARDUST ROOM**

THE SHIPBUILDING TECHNOLOGY TRANSFER PROGRAM
R. R. Roper. Levingston Shipbuilding

AN OVERVIEW OF THE NAVY's MANUFACTURING TECHNOLOGY PROGRAM
D. Carstater, Hq. NAVMAT

12:oo LUNCH

1:30 GENERAL SESSION **STARDUST ROOM**

IMPROVING LABOR PRODUCTIVITY IN SHIPBUILDING
L. E. Davis, Center for Quality of WOrking **Life**

THE ROLE OF OPERATIONS RESEARCH IN SHIPBUILDING
J. Low and S. Knapp, National Steel & Shipbuilding co.

THE SHIPYARD PRODUCT INFORMATION SYSTEM AS AN AID TO IMPLEMENTING MORE PRODUCTIVE STRATEGIES
D. J. Martin, IIT Research Institute

3:oo INFORMAL DISCUSSION PERIOD

3:30 Concurrent Sessions

SESSION 1 **STARDUST ROOM**

SEMI-AUTOMATIC PIPE PRODUCTION IN A SMALL SHIPYARD
B. Waring, Port Weller Dry Docks

THE AVONDALE PIPE SHOP: HARDWARE AND SOFTWARE STATUS
H. F. Arnold. Avondale Shipyards. Inc.

A PROGRESS REPORT ON THE CNC FRAME BENDER
D. Wall, National Steel & Shipbuilding Co., and F. Cali. Cali & Associates

SESSION 2 **TERRACE** ROOM

SHIPDS-SHIPLO: **A TWO-PHASE PROGRAMMING SYSTEM FOR THE DESIGN OF SURFACES IN SHIPBUILDING**
A. Weichbrodt. University of Utah

AUTOKON's **NEW STRUCTURAL DESIGN CAPABILITIES: MOVING INTO THE DRAWING ROOM**
P. Sorensen. **SRS A/S**

5:15 -6:30 RECEPTION **BLACK AND WHITE ROOM**
Sponsored by IIT Research **Institute**

WEDNESDAY, SEPTEMBER 12

8:00 -3:30 REGISTRATION **FOYER**

8:30 GENERAL SESSION **STARDUST ROOM**

NETWORK SCHEDULING OF SHIPYARD PRODUCTION. ENGINEERING AND MATERIAL PROCUREMENT
M. Boucher. SPAR Associates

PLANNING AND SHIP OUTFITTING PRODUCTION CONTROL AT NEWPORT NEWS
J. Bollinger. Newport News Shipbuilding & Dry Dock Co.

OUTFIT PLANNING
L. D. Chirlllo, Todd Pacific Shipyards, and C. Jonson. Science Applications, Inc.

AN ITEGRATED INTERACTIVE PLATE NESTING AND MANUFACTURING PLANNING SYSTEM
J. M. Wallent and P. M. **Cofoni. General Dynamics Corp.**

10:30 INFORMAL DISCUSSION PERIOD

11:00 **Concurrent Sessions**

SESSION 1 — **STARDUST ROOM**

COST-EFFECTIVE N/C PROCESSING IN A SMALL SHIPYARD
W. Shipley, Merinette Marine Corp., and F. Call, Cell & Associates

AUTOKON-76/79 - **AN AFFORDABLE IMPLEMENTATION ON PRIME MINICOMPUTERS**
J. Gude. SRS. Inc.

SESSION 2 — **TERRACE ROOM**

MINICOMPUTER APPLICATIONS FOR LONG RANGE PLANNING
L. D. Eddy. National Steel & Shipbuilding Co.

SEAS - **A COMPUTER MODEL FOR MANAGEMENT DECISION MAKING**
J. Forman and J. Hotaling. Maritime Administration. U.S. Department of Commerce

12:00 LUNCH

1:30 **Concurrent Special Interest Group Meetings**

SESSION 1 — **STARDUST ROOM**

EXPLOITING DATABASE MANAGEMENT SYSTEMS IN SHIPBUILDING
Moderator: 0. J. Wolanyk, National Steel & Shipbuilding Co.

SESSION 2 — **TERRACE ROOM**

PLANNING & PRODUCTION CONTROL FOR SMALL AND MEDIUM SIZE YARDS
Moderator: J. Sligar, Jeffboat, Inc.

SESSION 3 — **TOWER ROOM**

COMMON SHIPYARD INFORMATION SYSTEM AND DATA PROCESSING PROBLEMS
Moderator: D. Spanninga, National Steel & Shipbuilding Co.

3:00 INFORMAL DISCUSSION PERIOD

3:30 - 7:00 TOURS
-National Steel & Shipbuilding Co.
-Atkinson Marine Corp.

THURSDAY, SEPTEMBER 13

8:00 -11:00 REGISTRATION — **FOYER**

8:30 **Concurrent Sessions**

SESSION 1 — **STARDUST ROOM**

AUTOPART. AUTONEST. AUTODRAW - **SYSTEMS FOR INTERACTIVE LOFTING**
P. Sorensen, SRS A/S

APPLICATION OF THE GIFTS-5 MINI-BASED GRAPHICS SYSTEM FOR SHIP DESIGN & ANALYSIS
H. A. Kamel. University of Arizona

DATA PROCESSING TRENDS AT ITALCANTIERI: PRESENT SOFTWARE PRODUCTS AND FUTURE PLANS
P. Banda. Italcantier S.P.A.

SESSION 2 — **TERRACE ROOM**

INCREASED SHIPBUILDING PRODUCTIVITY THROUGH PRODUCTION ENGINEERING
F. H. Rack, Shipbuilding Consultants, Inc.

DESIGN FOR PRODUCTION
J. D. F. Craggs and R. Vaughan, A&P Appledore International, Ltd.

GROUP TECHNOLOGY AND AUTOMATED PROCESS PLANNING. A CHANGE IN MANAGEMENT STRATEGY
A. Hautzeel, TN0 Orgenization for Industrial Research

10:30 INFORMAL DISCUSSION PERIOD

11:00 GENERAL SESSION — **STARDUST ROOM**

INTEGRATING SHIPYARD DESIGN AND MANUFACTURING FUNCTIONS INTO AN EXISTING CAD/CAM SYSTEM
P. Hanratty. Manufacturing & Consulting Services. Inc.

CURRENT STATUS OF THE LOW COST PARTS DEFINITION PROJECT
R. C. Moore, Newport News Shipbuilding & Dry Dock Co.

12:00 LUNCH

1:30 GENERAL SESSION **STARDUST ROOM**

SEABIRD - **AN INTEGRATED ONLINE INTERACTIVE GRAPHICS SYSTEM FOR SHIP DESIGN**
Y. Horiba. Ishikawajima-Harima Heavy Industries Co., Ltd.

SHIPBUILDING STEEL - U.S. VS. JAPANESE PHILOSOPHIES
E. E. Mayer, Levingston Shipbuilding

ICCAS '79 **HIGHLIGHTS**
R. C. Moore, Newport News Shipbuilding &k Dry Dock Co.

SIG SUMMARIES

1) EXPLOITING DBMS IN SHIPBUILDING
0. J. Wolanyk

2) PLANNING AND PRODUCTION CONTROL FOR SMALL AND MEDIUM SIZE YARDS
J. Sligar

3) COMMON SHIPYARD INFORMATION SYSTEM AND DATA PROCESSING PROBLEMS
D. Spanninga

3:oo ADJOURNMENT

APPENDIX B: ATTENDANCE LIST

REAPS TECHNICAL SYMPOSIUM

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SAN DIEGO, CALIFORNIA
SEPTEMBER 11-13, 1979

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